Weather Event Simulator

Simulation Guide: *August 11, 1999 Event*

Presented by the

Warning Decision Training Branch

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Ed Mahoney, Chief

Warning Decision Training Branch
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Document History

The document history is provided to track updates and changes to the simulation guide. The version number, seen at the bottom of every page will be updated as each significant change is made to the simulation guide.

Version	Date	Description
1.0	31 May 2002	Initial release.

Note: the date of modification is listed on the cover page.

To provide feedback, comments or ideas related to this document, please visit our web site at: http://wdtb.noaa.gov

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1: How to Use This Document

I. Introduction

Welcome to the ***August 11, 1999*** Simulation Guide! The purpose of this guide is to provide the trainer at a forecast office with guidance on preparing and delivering effective severe weather simulations using this case. This guide is being released in accordance with the Weather Event Simulator Integration and Operations Plan (WES IOP).

Since this document outlines the "answers" to the challenges of the event, it is specifically meant for the use of the trainer only.

A simulation can be as simple (view data and practice using WarnGen) or as involved (pause simulation to discuss warning decisions and the impacts of all data on these decisions) as needed. ***The simulation content and length can be modified depending on the time available for training, the needs of the trainee, and the focus of the training.*** The simulation can focus on the technology alone, the science alone, or the interactions between these two and the human decision maker (i.e. simulating an actual event). This guide is the fourth in a series of training guides, each associated with specific cases identified in the WES IOP. With this guide, the trainer can summarize the key points of a particular case, choose the type of simulation appropriate for the trainee, and then see an example of how to run that simulation type.

See Table 1-1 for a description of the layout of this document.

Table 1-1: Simulation Guide Layout

How to Use This Document	
Introduction	The introduction describes contents of the simulation guide and how to use this document.
Simulation Types	This section provides a brief, generic description of the various simulation types presented in this document. Read this section to help you decide which type of simulation best fits the needs of the trainee (e.g., one which focuses on interpretation skills, or the use of AWIPS, or timing capabilities, or all the above).

Table 1-1: Simulation Guide Layout

The August 11, 1999 Event	
Overview	The event overview provides a summary of the key components of this event. Read this section to get a brief overview of the type of weather or challenges associated with the case.
Prepared Simulations	
Real Time Simulation Interval Based Simulation Situation Awareness Simulation Virtual Reality Simulation	Prepared simulations are provided in this portion of the simulation guide. Each one contains directions on when to start/stop the simulation, objectives, tasks, expected results, and talking points to help hone in on certain features.
Supporting Data	
Storm Reports	Storm Reports contains a graphical plot of Storm Data and a text list of Storm Data valid for the simulations.
SPC Products	SPC Products contains graphical plots of the watches/outlooks and text discussion SPC products.
Support Materials	Support Materials contains a CWA map, a useful form for documenting issued warnings and advisories, and a mesonet plot.

To prepare to run a simulation, the trainer should read ***How to Use This Document*** as the background necessary to choose and deliver effective simulations. The trainer may wish to modify the provided simulations, or develop their own simulations with specific learning objectives. The prepared simulations are the “scripts” designed for one-on-one training, where ***trainer and trainee participate together for the optimum learning experience***. Training research indicates this is the most effective way to run a simulation. Experience gained from running simulations can be used to guide future training activities.

In order to manage a simulation session, the trainer must be able to run a simulation as documented with the WES install and testing instructions included with the WES software. The simulations will be much more relevant if local WarnGen templates and procedures are created on the WES machine or moved over from the local AWIPS prior to running the simulations. For more detailed information on these techniques as they become available, visit http://www.comet.ucar.edu/strc/wes/.

II. Simulation Types

Real-time Simulation

A real-time simulation focuses on mastering warning mechanics and developing routines where the simulation runs from start to finish without interruption. The training objective is to demonstrate effective and timely manipulation of AWIPS data and applications (e.g., WarnGen) for the purpose of developing timely warning products.

Interval-Based Simulation

An interval-based simulation focuses on detailed discussions of critical warning points utilizing pauses in the simulation. The training objectives are to demonstrate methods of data interpretation, effective use of AWIPS data, proper type and content of warnings, and weighing information in the decision making process. In addition, the trainee should demonstrate ways to handle uncertainty in the warning decision making process.

The objectives of the interval-based simulation are achieved by the **trainer and trainee** working together through a simulation that is occasionally paused to invoke the question-and-answer process. Direct observation of actions taken by the trainee during important decision points during the simulation can provide excellent opportunities for the trainer to discuss applications of effective warning decision making.

Situation Awareness Simulation

A situation awareness simulation focuses on evaluating the trainee's ability to maintain ***three levels of situational awareness***. These are:

1. **Perceive** the warning inputs (*e.g., A spotter reports rotation*),
2. **Comprehend** the meaning of these inputs (*e.g., Together with velocity information, this indicates a high probability of a tornado.*),
3. **Project** this meaning into expectations and action (*e.g., A tornado warning is required along and slightly to the right of the storm's path.*).

For this level of simulation, the trainer will occasionally pause the simulation to query the trainee on interpretation of events. Through this process, the trainer attempts to deduce whether the trainee is maintaining all three levels of situation awareness. The training objective at this level of simulation is to ***demonstrate awareness of the situation***.

As in the interval-based simulation, monitoring of the trainee's level of situation awareness and subsequent decision-making process is only achieved via the trainer's questioning on the methodologies and conceptual models used in the decision-making process.

Virtual Reality Simulation

The virtual reality simulation mode is intended to most closely resemble what can happen in the office for a real event. The training objective of the virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. For example, the trainer might provide conflicting information (spotter reports without supporting radar data) or interject problems (primary radar data unavailable) that the trainee has to react to and overcome during the simulation. This simulation focuses on the highest level of performance and critical thinking skills that should be present with an expert warning forecaster. Running the expert forecasters on staff first through the virtual reality simulation may be a good place to start using WES to enhance a local training plan. Experiences in this simulation can be used to incorporate local knowledge and expertise into future simulations for other forecasters on staff.

The *August 11, 1999* Event

Overview

In the early afternoon of August 11th 1999, an unanticipated round of severe weather developed over northern Utah and Southern Idaho (for a plot of storm data and the report list, see Appendix A.). The storms developed in association with a mid-level shortwave and upper-level jet streak moving across Utah in the early afternoon. Instability estimated by modifying the morning sounding with the 17 UTC SLC surface observation was low (surface-based CAPE ~ 830 J/kg) over the SLC area, though it may have been higher (~ 1800 J/kg) over part of the CWA due to cold air aloft suggested by satellite and the LKN sounding. Surface to 400mb wind shear was also weak-moderate (25-35 kts), with the stronger shear over cental and southeast Utah. Attaining situation awareness is difficult in this case because the environmental forecasts are marginally supportive of severe weather.

Although numerous storms developed with marginal severe weather signatures across the CWA, only two storms (which happen to move over the more populated areas) have severe weather reported with them. The lack of severe weather reports with many of the storms could be related to areas of sparse population; however, most of these storms did not look as intense as the two with reports. One of the stronger storms, which occured in southern Salt Lake County, displayed marginal supercell characteristics. This storm produced 0.75-1.5” hail.

The most significant storm of the day evolved from a cluster of cells that developed just west of Salt Lake City in northern Salt Lake County. This storm interacted with a boundary to produce an F2 tornado, 1.5” hail, and wind gusts to 52 kts in downtown Salt Lake City. One fatality and 80 injuries occurred with this tornado. The boundary, which may have had some origins from the Great Salt Lake breeze, is not well defined in the WSR-88D data due to sampling limitations. However, Terminal Doppler Weather Radar (TDWR) data (not available operationally) clearly shows the upward developing mesocyclone on the windshear line with the boundary. The rapid development of the small area of rotation, coupled with noisy velocity data, make this a challenging event to anticipate and warn for. For more information on this event, including a TDWR analysis, see Dunn and Vasiloff (WAF 2001).

2: Real Time Simulation

I. Introduction

This real-time simulation example focuses on the central part of the CWA (Salt Lake and Davis Counties) containing multiple storms, two of which have severe weather reported with them. The manageable workload with these storms allows the trainee time to focus on using WarnGen and developing timing skills. This simulation is appropriate for a novice warning forecaster who has been exposed to using WarnGen and can benefit from focusing primarily on the mechanics of issuing warnings.

Objectives

The training objectives of this real-time simulation are to demonstrate:

- Ability to effectively use WarnGen to create warnings.
- Ability to effectively use WarnGen to issue severe weather statements as a follow up warning product.
- A timely routine for calling up products to evaluate the threat for tornadoes, hail, wind, and flooding.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide), have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Obtain a summary shift change briefing by the trainer.

Simulation: Issue warnings and follow up statements for Salt Lake and Davis Counties.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation and give a shift change briefing summarizing the threat for all severe weather types (tornado, hail, wind, flooding).

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This real-time simulation is designed to take 2.75 hours to complete, with 15 minutes for the pre-simulation briefing, 2 hours for the simulation, and 30 minutes for the post-brief. As with all simulation examples, times can be adjusted as needed. The simulation starts at 1745 UTC on August 11th, 1999 and ends at 1945 UTC on August 11th, 1999. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainer to briefly describe the threat for severe weather (tornado, hail, wind, and flash flooding) to the trainee. The trainer should step through the following tasks to prepare the simulation.

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.
2. Print out the warning log from Support Materials (see page C-2) so the trainee can keep track of the warnings they issue.
3. Print out the mesonet plot from Support Materials (see page C-4) so the trainee can see the latest high-resolution surface data.
4. Close down any existing D2D sessions, and start the simulator for the time period 1745 UTC on August 11th, 1999 to 1945 UTC on August 11th, 1999.

5. Stop the simulator immediately to allow the trainer to brief the trainee on the environment up to the start time.

6. Start a D2D session, and if the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures, or the trainer may wish to build them for the trainee.

7. Provide a pre-simulation briefing for the trainee. Some elements that may be used include:

- Eta forecast sounding for SLC at 18 UTC contains ~ 1240 j/kg of surface based CAPE (SBCAPE) and ~ 25 kts of sfc-400 mb shear.
- Surface dewpoints at 17 UTC in the low 50°Fs with patches of low- and midlevel clouds indicative of relatively high values of boundary layer moisture.
- Morning thunderstorms in southern ID indicate atmosphere is convectively unstable.
- Upper-tropospheric trough with a significant cold pool centered over NV at 12 UTC is moving over the CWA. The leading edge of the cold pool is marked by the leading edge of colder brightness temperatures in the GOES-10 water vapor imagery. That leading edge reaches the Salt Lake Valley by 16 UTC.
- The morning Skew-T at SLC modified with the 17 UTC SLC observation (74/50) yields a SBCAPE of 830 j/kg with a significant amount of instability in lower levels (0-3 km). Further modifying the SLC conditions with mid and upper-tropospheric temperatures within the cold pool as sampled by the Elko, NV sounding, reveals an SBCAPE of 1800 j/kg.
- There is no CIN with a surface T=74^{o}F and Td=50^{o}F at SLC with either the SLC or the EKO mid and upper-level tropospheric temperatures.
- 0-6 km shear from the RUC80 model (calculated by the volume browser in CONUS scale) is weak because of highly veered boundary-layer flow, and the 500 mb flow used in the 6 km approximation is not representative of the 6km AGL layer. The shear weakens throughout the day as the cold core moves closer. Using the volume browser to subtract the surface from 400 mb winds yields slightly higher shear from 25-30 kts. However, the surface winds analyzed by the RUC80 are too veered relative to the observations. Although the VWP from KMTX also shows similar winds at 400 mb compared to the RUC (225^{o} 25kt), stronger winds are suggested by LAPS just to the south of the Great Salt Lake. The LAPS analysis at 17

UTC shows 40 kt winds at 400 mb to the south of the Great Salt Lake (in the warning area) and southerlies at the surface.

- Near surface winds of 180^{o} at 14 kts found in the 17 UTC SLC metar, and southwest winds of 35-40 kts at 400 mb in the 17 UTC LAPS over SLC, yields an approximate 0-6 km shear of 30-35 kts. This is at the lower margins for expecting organized supercells, even with the more liberal shear-estimate. Typical supercell values would be around 40 kts and higher. Note that 400 mb is used to approximate the 6 km layer above ground.
- Southerly (15 kt) valley floor winds (4 Kft MSL) and the 245^{o} 15kt at 8 Kft MSL combine to make low-level (0-1 km) shear values of about 10 - 15 kts. The weak shear and low 0-1 km SRH indicate a low chance of supercell tornadoes without local modification of the environment.
- 17 UTC dewpoint depressions are running from 20 - 24^{o}F (with higher values expected as heating continues) yielding mixed LCL heights around 1500 m, which is above those values associated with 95% of significant (> F1) tornadoes.
- Steep lapse rates, no CIN, and potentially 1800 j/kg SBCAPE in the presence of 25-35 kt shear indicate the potential for moderately strong updrafts. Although shear is marginal for supercells, should any occur, the potential for larger size hail will be higher. In addition, the wetbulb-zero heights around 7.2 kft AGL and dry air in the boundary layer indicate limited melting of any hailstones.
- Severe downbursts are possible given the 20-24^{o}F surface dewpoint depressions (higher values expected with more heating) and estimated CAPE. Lateral dry air entrainment may be limited owing to moist air at midlevels. Surface to 550mb theta-E depressions are small (10-15K), indicating limited potential for downdraft forcing from lateral dry air entrainment.
- This environment is not significantly moist such as in a true monsoonal pattern. However, given the estimated CAPEs and the potential for cell training over steep terrain with sufficiently low LCLs, some flash flooding is possible.
- Convection initiation sources include areas of high terrain intersecting locally enhanced regions of low- and midlevel moisture. Other initiation sources include a northeast-southwest oriented boundary lying just south of the Great Salt Lake at 17 UTC as observed by several mesonet stations. The origins of the boundary may be a lake breeze or another source, such as from previous convection.

8. Discuss the warning sector issues, and have the trainee warn for Salt Lake and Davis Counties. The trainer may wish to adjust the warning sector based on the skill of the trainee.

9. Inform the trainee that the flash flood guidance for the SLC CWA is approximately 1.5” for one hour, and 3” for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in an area of general thunder, and no watch is in effect.

11. Summarize that the expected severe weather types are severe hail and damaging winds. Flash flooding is possible with slow storm motion and any training of cells. Supercell tornado threat is low.

III. Simulation

The training objectives of this real-time simulation are to demonstrate:

- Ability to effectively use WarnGen to create warnings.
- Ability to effectively use WarnGen to issue severe weather statements as a follow up warning product.
- A timely routine for calling up products to evaluate the threat for tornadoes, hail, wind, and flooding.

This 2 hour simulation starts at 1745 UTC on August 11th, 1999, and ends at 1945 UTC on August 11th, 1999. The trainee will be asked to warn for the sector containing Salt Lake and Davis Counties. The trainer should refer to the Section V Trainer Evaluation Guide to assist in determining the target storms and evaluating trainee performance.

Trainer Tasks

1. Explain the objectives to the trainee (see page 2-1).

2. State to the trainee that:

- There will be no pauses during the simulation.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 1745 UTC on August 11th, 1999, to 1945 UTC on August 11th, 1999. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Take about 10 minutes to show the trainee how to create a warning, follow-on severe weather statement, and how to save it to a file. To export a warning to a file after the warning has been typed up:
   - In the text editor, click under “File”, “Export to File...”.
   - Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.
5. Inform the trainee to take 5-10 minutes to set up their D2D sessions and start warning operations.
6. During the simulation, provide storm reports as spotter reports. Use the reports listed in Appendix A or the storm tables in theTrainer Evaluation Guide on page 2-7 (consult image in Appendix A for graphical locations).
7. Evaluate the trainee’s ability to issue timely severe weather products and their warning routines using the Trainer Evaluation Guide on page 2-7.
8. At the end of the simulation, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of this post simulation briefing is to discuss the trainee’s ability to issue timely severe weather products and their warning routines used in the simulation. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the simulation to focus discussion on relevant issues.

Trainer Tasks

1. Ask the trainee to self evaluate performance on:
   - Using WarnGen to create warnings.
   - Using WarnGen to issue severe weather statements as a follow-up warning product.
   - Demonstrating a routine for evaluating threat for tornadoes, hail, wind, and flooding.

2. Discuss the observations of performance noted during the simulation. Utilize the warning files that were saved in the evaluation process.
3. Consider reviewing the TDWR data to discuss radar sampling issues using the following website: http://www.wdtb.noaa.gov/resources/tutorials/11aug99/summary.htm
4. Discuss the key issues of the event and any lessons learned, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The focus of the real-time simulation is not on whether correct warning decisions were made; rather, it is on whether the warnings and severe weather statements were created properly and efficiently, and whether appropriate warning routines were used to evaluate the severe weather potential. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation. The Warnings, Severe Weather Statements, and Methodology sections below are to be used to evaluate the trainee, while the considerations included with each storm table are for the trainer to become more familiar with the storms and warning issues.

Warnings

- Is the method of calculating the storm motion with WarnGen adequate? Does the trainee start at the end of a loop of 0.5° reflectivity and step back 3-4 frames before dragging the circle to the feature being tracked? Does the trainee step through the loop to insure the tracking is adequate and to correct any errors?
- Does the trainee click on the Redo Box button to redraw the box after obtaining an adequate storm motion?
- Does the trainee modify the polygon appropriately next to county boundaries? Are all the counties in the polygon selected correctly before the warning text is created?
- Is the duration of the warning appropriate for the workload?
- Does the trainee utilize the appropriate product type and optional bullets in choosing the text? Is the text modified to discuss only the primary threats specific to the storm being interrogated? Are they over-using call

to action statements? Is the magnitude of the threat conveyed clearly in the warning (e.g. quarter size or baseball size hail)? Are spotter observations mentioned in the text?

- Does the trainee appear to read the warning before sending it out? Are there text mistakes in the warnings?
- Are the important cities in the path of the storm identified in the warning?
- If pathcasting is being used, is it overly precise given the uncertainty in the movement of the storm?
- Is the trainee falling behind in monitoring all the storms because of problems using WarnGen?

Severe Weather Statements

- Is the polygon moved and resized reasonably to where the storm is at the latest 0.5° reflectivity image in the loop?
- Is any new pertinent information being included in the statement (storm has intensified, weakened, showing signs of even larger hail)?
- Are the follow-on statements timely given the workload (at least one per warning)?
- Does the content of the statement reflect the locations and general content of the original warning?

Methodology

- Does the trainee evaluate each severe weather threat prior to creating the first warning?
- Are the product choices optimal for evaluating the threat?
- Is the trainee using all tilts Z/SRM to evaluate the latest data and three dimensional storm structure?
- Is the choice of tilts in the 4 panel chosen appropriately to sample the low, middle, and upper levels of the storm to look at temporal changes in the evolution?
- Is SRM being used to evaluate rotation?
- Is the 0.5° base velocity periodically checked for signs of strong ground-relative winds even though the wind threat is not high?
- Are the radar estimated precipitation totals being checked occasionally?

- Are the reflectivity characteristics in middle and upper levels being evaluated with all tilts Z/SRM and VIL for high reflectivity cores aloft for evaluating hail threat?
- Is base data used along with derived products (VIL, CR, radar algorithms)?
- Is satellite data being monitored for cold cloud tops and overshooting tops?
- Is lightning data being used to look for dense clusters of cloud to ground lightning indicating strong updrafts?
- Are changes in objective analysis fields such as MSAS LI, LAPS CAPE/CIN, etc. being investigated at some time during the simulation?
- Are raw observations of the environment being investigated (surface obs, KMTX VWP)?
- Are meso-analysis fields reviewed when the new surface observations are in at the top of the hour and when the new objective analysis fields are in at 20 minutes after the hour?
- Is the most recent data always being accessed when evaluating a storm?
- Is the trainee relying explicitly on the hail algorithm maximum estimated hail size in the warning, or are is the algorithm output used as general guidance?
- Is the trainee able to perform tasks and still keep up with new incoming data?

General Issues

Time (UTC)	Description
1700-2005 KMTX	radar data time period

Considerations

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?

- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, or MSAS/LAPS)?
- Does the trainee recognize that objective analysis fields are more problematic in mountainous regions due to terrain effects and the lack of observations?

Storm Summary

During this real-time simulation there are multiple storms to monitor in and around Salt Lake and Davis Counties. The two strongest storms have severe weather reported with them as they move through Salt Lake County, while other weaker storms move through Davis County. The first strong storm exhibits some marginal supercell characteristics in southern Salt Lake County, where it produces 0.75-1.5" hail.

Just to the north of the intense storm in southern Salt Lake County, another cluster of cells develops on a boundary just south of The Great Salt Lake. (See the mesonet plot; Figure C-3 on page C-4.) This boundary appears to have origins associated with lake breeze from the Great Salt Lake. A rotating updraft (captured on video) develops from these cells acting on the boundary, where a weak to moderate strength mesocyclone, with weak-moderate gate-gate shears, develops upward from the shear axis on the boundary, displayed well in non-operational radar data sets (TDWR). The radar depiction of rotation is hampered by the noisy velocity data around the area where the tornado develops, the long range from the radar, and the high beam height at 0.5 degrees due to the elevated radar location. A tornado develops with this storm as it moves through downtown Salt Lake City, producing primarily F1 damage with some F2 damage. One fatality and 80 injuries occurred with the tornado. The storm also produces wind gusts to 52 kts and hail to 1.5".

The Southern Salt Lake County Storm (1730-1945 UTC)

Time (UTC)	Description
1730 GOES-10	South end of -30^{o}C tops.
1734 KMTX	Two elevated 40dBZ cores @ 156^{o} 55 nm. VIL < 20 kg/m^{2}.
1745 GOES-10	Southern end of north-south oval of anvil top. Min CTT= -38^{o}C.

Time (UTC)	Description
1751 KMTX	Cores consolidated. Ref gradient and small WER at @ 168^{o} 53 nm; 50 dBZ to 22 kft MSL;
1756 KMTX	VIL increased to 25 kg/m^{2}; Cell becomg kidney-shaped; Weak cyc circulation V_r=10kts 22kft MSL.@ 169^{o} 55 nm.
1801 KMTX	Cyc circulation weakened; 55 dBZ to 26.5 kft MSL; Small WER; VIL increased to 30 kg/m^{2}.
1806 KMTX	WER increased in width but 55 dBZ fell to 21 kft MSL;
1812 KMTX	Increased convergence at 0.5^{o} slice just west of notch;
1816 KMTX	missing 2.4-9.9 deg slice. VCP switch to 11. Conv rotation increased to V_r=15 kt in lowest two slices @162^{o} 52 nm.
1821 KMTX	55 dBZ up to 31 kft MSL; WER almost a BWER @160° 51nm on the 2.4°°slice. VIL=35 kg/m^{2};
1826 KMTX	Weak (V_r=20kt) meso lowest 3 slices. 1.5^{o} slice showed the most symmetry; VIL=40 kg/m^{2}; MEHS to 1.5”
1830 GOES-10	CTT min with overshoot = -47^{o}C; Surrounding anvil around -42^{o}C.
1831 KMTX	Meso weakened, no significant circulation. Strong WER continues @158^{o} 51 nm.
1836 KMTX	Lost lowlevel inflow notch in reflectivity; Convergent signature in lowest slice. Weak rotation further aloft (V_r=10kt).
1815 LSR SLC	LSR #1; 1.5” hail in Herriman, Salt Lake CO. Note: the 1800-1815 UTC report was put here because the storm did not reach Harriman until 1815 UTC.
1841 KMTX	55 dBZ still up to 30 kft MSL; OHP shows 1.5” @ 160^{o} 49 nm.
1845 GOES-10	CTT min up to 46^{o}C; Still a well defined overshoot.
1846 KMTX	MEHS down to 1”; New cores forming upstream.
1851 KMTX	55 dBZ down to 20 kft MSL; MEHS < 1”; VIL down to 35 kg/m^{2};
1901 KMTX	55 dBZ surged up to 30 kft MSL @ 150^{o} 49 nm;
1911 KMTX	55 dBZ down to 20 kft MSL;
1830-1840 LSR SLC	LSR #2; 3/4” hail in Sandy City, Salt Lake CO. Note: the time does not match the radar data.

Time (UTC)	Description
1915 GOES-10	CTT min = -46^{o}C. Overshooting top well defined.
1916 KMTX	55 dBZ down to 11 kft MSL; VIL down to 25 kg/m^2; MEHS < 1”. STP shows 2”, likely some hail contamination. OHP~1.5-2”.
1926 KMTX	35 kt DV@ 144^{o} 52 nm - 1.5^{o} slice; No time or height continuity. Although there is a small elevated core.
1930 GOES-10	CTT min = -45^{o}C; overshoot is ill-defined.
1945 KMTX	STP at 2” with some overestimation.

Considerations:

- Does the trainee notice the onset of a WER and a sharp reflectivity gradient curved in a concave manner on the storm’s southern flank at 1756 UTC? The reflectivities are still low but the shape of the core suggests a relatively strong updraft.
- Does the trainee notice the increased velocity convergence and circulation in the lowest few slices at 1811 UTC? The values are still weak, but they suggest a strengthening updraft.
- Does the trainee notice the onset of an elevated 55 dBZ core extending up to 26 kft MSL at 1801 UTC?
- Does the trainee analyze the hail size potential of this storm and then compare it to the MEHS in the HDA?
- Does the trainee notice that this storm is accompanied by new upstream cell initiation and cell training is occurring over the area west of Sandy and I-25?
- Does the trainee notice the hourly rainfall amounts in excess of 2 inches west of Sandy and I-25?
- Does the trainee factor in hail contamination, possibility of surface drainage, and terrain if a flash flood warning is considered?

Toole-Davis County Storm (1816-1846 UTC)

Time (UTC)	Description
1816 KMTX	VIL 35 kg/m^2, MEHS 0.75”

Time (UTC)	Description
1821 KMTX	55 dBZ to 25 Kft AGL, areal increase in 35 kg/m2 VIL, MEHS 1”, POSH and POH 100%, 1.5-2” OHP
1826 KMTX	55 dBZ to 24 Kft AGL, VIL increase to 40kg/m^2; MEHS=1.25”, 60 dBZ first appears at 4 Kft AGL
1830	IR cloud top temperature min -44^{o}C (warmer than storms to the south)
1831 KMTX	55 dBZ to 23 Kft and 40 dbz to 30 Kft
1846 KMTX	reflectivity weakens aloft as storm enters its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over the Great Salt Lake, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Salt Lake-Morgan County Storm (1830-1916)

Time (UTC)	Description
1830	IR cloud top temperature min -47^{o}C
1831 KMTX	50 dBZ to 24 Kft and 45 dBZ to 30 Kft, 60 kt gate-to-gate delta V only at lowest tilt (5 Kft AGL) and in an area of noisy velocity data, well defined divergence aloft (85 kt delta V)
1836 KMTX	50 dBZ to 29 Kft and 45 kBZ to 33 Kft, VIL 30 kg/m^2, MEHS 0.75”, weak mesocyclone-scale rotation (20-25 kts at 36 nmi) forming through a deep layer, weak TDA detection with a 56 knot LLDV
1841 KMTX	50 dBZ to 28 Kft and 45 dBZ to 34 Kft, MEHS 1”, POSH and POH 100%, weak TDA detection (50 kt LLDV) continues, velocity data less noisy, rotation increases to moderate strength (30 kt V_r at 38 nmi)

Time (UTC)	Description
1841-1855 SLC	LSR#3: F2 tornado in Salt Lake City
1845	IR cloud top temperature min -47^{o}C expands
1846 KMTX	55 dBZ to 25 Kft, mesocyclone rotation strengthens to 35 kt V_r, weak TDA detection (58 kt LLDV) continues, VIL increase to 45 kg/m^2; MEHS=1.25”, POSH and POH 100%, large area of 55 dBZ at 5 Kft
1851 KMTX	weak 40 kt gate-to-gate low-level delta-V, rotation weakened through a deep layer
1856 KMTX	1.5-2” OHP
1900 SLC	LSR#4: G52 kts in North Salt Lake
1901 KMTX	VIL increase to 30 kg/m^2 again
1915-1920 SLC	LSR#5: 1.5” hail in Bountiful
1916 KMTX	reflectivity weakens aloft as storm moves over 8 Kft MSL mountains where it begins its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with the high reflectivity cores aloft early in the storm’s lifetime?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee recognize the noisy velocity data over downtown Salt Lake City at the lowest elevation angle, and therefore put less faith in the velocity data prior to 1841?
- Does the trainee recognize the development of organized weak rotation at 1836 UTC?
- Does the trainee utilize the TDA in their analysis? If not, does the trainee recognize the weak-moderate TVS signatures in the base data?
- Does the trainee recognize the increased rotation during the 1841 and 1846 volume scans gives more credence to the tornado threat?
- Does the trainee cancel the warning prematurely when the radar signature weakens?

- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee anticipate the threat to diminish when the storm moves east of Salt Lake City into the mountains?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Davis County Storm (1921-2000 UTC)

Time (UTC)	Description
1916 KMTX	1.5” OHP estimate
1921 KMTX	50 dBZ to 25 Kft, VIL 30 kg/m^2, MEHS 0.75”
1926 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m2, MEHS 0.75”
1930	IR cloud top temperature min -47^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL increase to 35 kg/m^2; MEHS=1”
1935 KMTX	35 kg/m^2 VIL;
1940 KMTX	35 kg/m^2 VIL; MEHS=1”
1945 KMTX	40 kg/m^2 VIL; MEHS=1”
1945	larger area of -47^{o}C IR cloud top temperature min
1955 KMTX	30 kg/m^2 VIL; MEHS=0.75”
2000 KMTX	55 dBZ to 27 Kft, 30 kg/m^2 VIL; MEHS=0.75”

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?

- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Northeastern Toole County Storm (1931-2000 UTC)

Time (UTC)	Description
1931 KMTX	50 dBZ to 26 Kft AGL, VIL 30 kg/m^2; MEHS=0.75”
1935 KMTX	35 kg/m^2 VIL, MEHS 0.75”
1940 KMTX	VIL weakens to 25 kg/m^2, MEHS 0.75
1945 KMTX	MEHS=0.75”
1950 KMTX	large area of 55-60 dBZ reflectivities at 5 Kft, 50 dBZ to 24 Kft, MEHS 0.75
1955 KMTX	50 dBZ to 25 Kft, 30 kg/m^2 VIL, MEHS 0.75”
2000 KMTX	50 dBZ to 27 Kft, 40 kg/m^2 VIL, MEHS 1”, POSH and POH 100%, 1.5” OHP estimate

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

3: Situation Awareness Simulation

I. Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing numerous storms, one of which produces a significant tornado (F2 damage) in downtown Salt Lake City, and others that produce severe hail. This simulation is appropriate for a warning forecaster with intermediate level of expertise who is proficient with the mechanics of issuing warnings. At three times, unknown to the trainee, the simulation will be paused for the trainer to evaluate the trainee's situation awareness. To get the most out of this simuation, the trainer should consider **not** giving the tornado report as a spotter report during this simulation.

Objective

The training objective of this situation awareness simulation is:

- Demonstrate the three levels of situation awareness (perceive, comprehend, project) during a challenging warning situation.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing and sectorizing issues for this event.

Simulation: Manage the simulation, pause the simulation to query the trainee's level of situation awareness, evaluate the performance of the trainee, and interject spotter reports.

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This situation awareness simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for querying, and 30 minutes for the post-brief. The simulation starts at 1745 UTC on August 11th, 1999 and ends at 1945 UTC on August 11th, 1999. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sectorization issues.
2. Print out the warning log from Support Materials (see page C-2) so the trainee can keep track of the warnings they issue.
3. Print out the mesonet plot from Support Materials (see page C-4) so the trainee can see the latest high-resolution surface data.
4. Close down any existing D2D sessions, and start the simulator for the time period 1745 UTC on August 11th, 1999 to 1945 UTC on August 11th, 1999.

5. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

6. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the SLC CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

7. Instruct the trainee to:
   - Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
   - Evaluate warning sectorization issues.
   - Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

8. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:
   - Eta forecast sounding for SLC at 18 UTC contains ~ 1240 j/kg of surface based CAPE (SBCAPE) and ~ 25 kts of sfc-400 mb shear.
   - Surface dewpoints at 17 UTC in the low 50°Fs with patches of low- and midlevel clouds indicative of relatively high values of boundary layer moisture.
   - Morning thunderstorms in southern ID indicate atmosphere is convectively unstable.
   - Upper-tropospheric trough with a significant cold pool centered over NV at 12 UTC is moving over the CWA. The leading edge of the cold pool is marked by the leading edge of colder brightness temperatures in the GOES-10 water vapor imagery. That leading edge reaches the Salt Lake Valley by 16 UTC.
   - The morning Skew-T at SLC modified with the 17 UTC SLC observation (74/50) yields a SBCAPE of 830 j/kg with a significant amount of instability in lower levels (0-3 km). Further modifying the SLC conditions with mid and upper-tropospheric temperatures within the cold pool as sampled by the Elko, NV sounding, reveals an SBCAPE of 1800 j/kg.
   - There is no CIN with a surface T=74^{o}F and Td=50^{o}F at SLC with either the SLC or the EKO mid and upper-level tropospheric temperatures.
   - 0-6 km shear from the RUC80 model (calculated by the volume browser in CONUS scale) is weak because of highly veered boundary-layer flow, and the 500 mb flow used in the 6 km approximation is not representative of

the 6km AGL layer. The shear weakens throughout the day as the cold core moves closer. Using the volume browser to subtract the surface from 400 mb winds yields slightly higher shear from 25-30 kts. However, the surface winds analyzed by the RUC80 are too veered relative to the observations. Although the VWP from KMTX also shows similar winds at 400 mb compared to the RUC (225^{o} 25kt), stronger winds are suggested by LAPS just to the south of the Great Salt Lake. The LAPS analysis at 17 UTC shows 40 kt winds at 400 mb to the south of the Great Salt Lake (in the warning area) and southerlies at the surface.

- Near surface winds of 180^{o} at 14 kts found in the 17 UTC SLC metar, and southwest winds of 35-40 kts at 400 mb in the 17 UTC LAPS over SLC, yields an approximate 0-6 km shear of 30-35 kts. This is at the lower margins for expecting organized supercells, even with the more liberal shear-estimate. Typical supercell values would be around 40 kts and higher. Note that 400 mb is used to approximate the 6 km layer above ground.
- Southerly (15 kt) valley floor winds (4 Kft MSL) and the 245^{o} 15kt at 8 Kft MSL combine to make low-level (0-1 km) shear values of about 10 - 15 kts. The weak shear and low 0-1 km SRH indicate a low chance of supercell tornadoes without local modification of the environment.
- 17 UTC dewpoint depressions are running from 20 - 24^{o}F (with higher values expected as heating continues) yielding mixed LCL heights around 1500 m, which is above those values associated with 95% of significant (> F1) tornadoes.
- Steep lapse rates, no CIN, and potentially 1800 j/kg SBCAPE in the presence of 25-35 kt shear indicate the potential for moderately strong updrafts. Although shear is marginal for supercells, should any occur, the potential for larger size hail will be higher. In addition, the wetbulb-zero heights around 7.2 kft AGL and dry air in the boundary layer indicate limited melting of any hailstones.
- Severe downbursts are possible given the 20-24^{o}F surface dewpoint depressions (higher values expected with more heating) and estimated CAPE. Lateral dry air entrainment may be limited owing to moist air at midlevels. Surface to 550mb theta-E depressions are small (10-15K), indicating limited potential for downdraft forcing from lateral dry air entrainment.
- This environment is not significantly moist such as in a true monsoonal pattern. However, given the estimated CAPEs and the potential for cell training over steep terrain with sufficiently low LCLs, some flash flooding is possible.

- Convection initiation sources include areas of high terrain intersecting locally enhanced regions of low- and midlevel moisture. Other initiation sources include a northeast-southwest oriented boundary lying just south of the Great Salt Lake at 17 UTC as observed by several mesonet stations. The origins of the boundary may be a lake breeze or another source, such as from previous convection.

9. Discuss the warning sector issues, and have the trainee warn for the SLC CWA covered by the KMTX radar. The trainer may wish to adjust the warning sector based on the skill of the trainee (e.g. consider creating a warning sector containing the storms in the central part of the CWA. If the CWA is sectorized, the trainee should adjust the focus of the discussion points accordingly).

10. Inform the trainee that the flash flood guidance for the SLC CWA is approximately 1.5” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in an area of general thunder, and no watch is in effect.

III. Simulation

The training objective of this situation awareness simulation is to demonstrate three levels of situation awareness during a challenging warning situation. This 2 hour simulation starts at 1745 UTC on August 11th, 1999, and ends at 1945 UTC on August 11th, 1999. At three times during the simulation (1826, 1845, 1940 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee’s situation awareness by evaluating:

- Has the trainee perceived data relevant to all the severe weather threats (spotter reports, expiration times of current warnings, etc.)?
- Does the trainee understand the meaning of the data? (What warnings are needed?)
- Has the trainee formed an expectation based on these data? (Will the threat change over time?)

For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 3-9.

Trainer Tasks

1. State to the trainee that:

- The objectives of the simulation are to demonstrate the ability to perceive warning related inputs, understand the meaning of the assessment and project this into expectations and actions.
- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the 2.0 hour simulation. At which times the trainer will ask.
    (1) “What is the current state of the severe potential and why?”
    (2) “What is the expectation of these storms in the next 30 minutes?”
    (3) “When will the current warnings expire?”
- If new warning sectors are defined, the trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing warning sectors.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 1745 UTC on August 11th, 1999 to 1945 UTC on August 11th, 1999. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.
- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in Appendix A, or the tables in the Trainer Evaluation Guide on page 3-9 (consult image in Appendix A for graphical locations).

6. At 1826 UTC pause the simulation for up to 10 minutes and ask:

    (1) “What is the current state of the severe potential and why?”
    (2) “What is the expectation of these storms in the next 30 minutes?”
    (3) “When will the current warnings expire?”

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has noticed the severe hail/wind threat for the storms in southern Salt Lake and northeast Box Elder Counties.

- If the trainee is “lost” or behind, document the reason. If corrective measures are needed to “reengage” them, make adjustments before resuming.

7. Resume simulation. Clear and reload any images loaded during the pause.

8. At 1845 UTC pause the simulation and ask:

(1) “What is the current state of the severe potential and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

(3) “When will the current warnings expire?”

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has recognized the rotation that has developed over northern Salt Lake County.
- If the trainee is “lost” or behind, document the reason. If corrective measures are needed to “reengage” them, make adjustments before resuming.

9. Resume simulation. Clear and reload any images loaded during the pause.

10. At 1940 UTC pause the simulation and ask:

(1) “What is the current state of the severe potential and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

(3) “When will the current warnings expire?”

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. In particular, evaluate whether the trainee has recognized the severe hail/wind threat for the storms in western Toole and eastern Morgan Counties and the more marginal severe threat in Cache, Davis, and northeastern Toole Counties.
- If the trainee is “lost” or behind, document the reason. If corrective measures are needed to “reengage” them, make adjustments before resuming.

11. End the simulation, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to consider in the discussion are:

- Maintaining a high level of situation awareness throughout.
- Recognizing multiple severe weather threats with the storms.
- Recognizing a rapidly evolving mesocyclone and tornado.
- The difficulty of perceiving and comprehending the cues in the data associated with the development of unanticipated events.
- Maintaining the big picture issues while periodically focussing on the details.

Trainer Tasks

1. Ask the trainee to:
- Discuss problems encountered with perceiving warning related inputs.
- Discuss any warning related inputs that were particularly challenging to understand.
- Discuss problems encountered with formulating expectations and actions.

2. Review the reports and the times to compare to the warnings.

3. Consider reviewing the TDWR data to discuss radar sampling issues using the following website:
http://www.wdtb.noaa.gov/resources/tutorials/11aug99/summary.htm

4. Discuss the key issues of the event and any lessons learned, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this situation awareness simulation is for the trainee to demonstrate the three levels of situation awareness (perceive, comprehend, and project) during a challenging warning situation. Part of the evaluation can be done during the query sessions, and more evaluation can be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1700-2005 KMTX	radar data time period

Considerations

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, or MSAS/LAPS)?
- Does the trainee recognize that objective analysis fields are more problematic in mountainous regions due to terrain effects and the lack of observations?

Storm Summary

During the simulation there are four areas of thunderstorm activity covered by the KMTX radar that require monitoring for severe weather in the CWA. The first area of deep convection to monitor is over northeastern Box Elder County around 1756 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail and heavy rainfall.

The second area to monitor is in the central part of the CWA in the Salt Lake City area from 1800-2000 UTC. Numerous thunderstorms occur over this area, two of which produce significant severe weather. The first strong storm exhibits some marginal supercell characteristics in southern Salt Lake County, where it produces 0.75-1.5” hail.

Just to the north of the intense storm in southern Salt Lake County, another cluster of cells develops on a boundary just south of the Great Salt Lake. A rotating updraft (captured on video) develops from these cells acting on the boundary, where a weak to moderate strength mesocyclone, with weak-moderate gate-gate shears, develops upward from the shear axis on the boundary, displayed well in non-operational radar data sets (TDWR). The radar depiction of rotation is hampered by the noisy velocity data around the area where the tornado develops, the long range from the radar, and the high beam height at 0.5 degrees due to the elevated radar location. A tornado develops with this storm as it moves through downtown Salt Lake City, producing primarily F1 damage with some F2 damage. One fatality and 80 injuries occurred with the tornado. The storm also produces wind gusts to 52 kts and hail to 1.5”. Numerous other storms with marginal severe hail signatures develop in the area of the Salt Lake City storm, though no severe weather is reported with the weaker storms.

A third area of convection to monitor occurs in easter Morgan County around 1921 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

A fourth area of convection to monitor occurs in easter Morgan County around 1931 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

Northeastern Box Elder and extreme Northwestern Cache County Multicell (1730-1945)

Time (UTC)	Description
1730 GOES-10	Isolated anvil with -38^{o}C CTT minimum.
1734 KMTX	55dBZ to 15.7kft and 50dBZ to 25 kft MSL@ 353^o 33 nm; Two adj cells; VIL < 30 kg/m^2. Weak midlevel conv N. cell.
1740 KMTX	55 dBZ to 21 kft MSL @ 357^o 31 nm; VIL < 30 kg/m^2; MEHS< 1”

Time (UTC)	Description
1745 GOES-10	CTT min dropped to -42^{o}C.
1746 KMTX	55 dBZ to 24 kft MSL @ 357^{o} 37 nm with the northern cell.
1751 KMTX	VIL increased to 30 kg/m^2 in northern cell.
1756 KMTX	VIL increased to 35 kg/m^2 in middle cell; New cell dvlped in S. flank @359^{o} 31 nm; MEHS = 1” in middle cell.
1801 KMTX	VIL increased to 40 kg/m^2 in northern end(357^{o} 40 nm). MEHS < 1”; Southern cell has 60 dBZ to 22 kft MSL (359^{o} 31 nm).
1806 KMTX	VIL down to 35 but MEHS up to 1”
1811 KMTX	OHP shows 1” at 357^{o} 37 nm; Area is on I-84.
1816 KMTX	Missing 2.4-9.9 deg slices. VIL increased to 40 kg/m^2
1826 KMTX	VIL remains at 40 kg/m^2 @ 008^{o} 34 nm.
1830 GOES-10	CTT min =-47^{o}C; A well defined overshoot.
1836 KMTX	55 dBZ up to 30 kft @ 010^{o} 34 nm;
1841 KMTX	OHP shows 1.5” @ 011^{o} 36 nm;
1845 GOES-10	CTT min up to -46^{o}C; Overshoot.becomes poorly defined.
1846 KMTX	New cell forming on south flank; VIL up to 45 kg/m^2.
1851 KMTX	New cell becmg dominant at 011^{o} 32 nm; 55 dBZ up to 28 kft.; VIL=35 kg/m^2.
1856 KMTX	WER on east and west flanks of new cell; OHP shows 2”.
1901 KMTX	VIL down to 30 kg/m^2;
1911 KMTX	STP up to 3”; Psbl hail contamination; 55 dBZ down to 13 kft MSL.
1915 GOES-10	No well defined CTT min; Overhead anvil around -44^{o}C.
1916 KMTX	VIL down to 25 kg/m^2; 55 dBZ only to 10 kft MSL; MEHS < 1”.
1930 GOES-10	New cell in N. Cache CO has CTT min = -48^{o}C; No well defined min for cells in far NE Box Elder CO.
1931 KMTX	VIL up to 30 kg/m^2 @ 49^{o} 31 nm; Cell has elevated core and is east of previous core in NW Cache CO. Western cell VIL still 25.

Time (UTC)	Description
1935 KMTX	Eastern cell 55 dBZ up to 20 kft.
1945 KMTX	OHP decreasing in NE BoxElder CO @014^{o} 37 nm. STP steady at 3”, likely with minor overestimation.
1945 GOES-10	CTT min with N. Cache CO. storm = -48^{o}C; No other CTT min nearby.

Considerations:

- By 1746 UTC, does the trainee understand the reason behind the low reflectivities in the lowest slice? The trainee should recognize that beam blockage is the cause.
- Does the trainee anticipate how the beam blockage may affect the VIL and hail algorithm results? The VIL may be decreased by 10-20%, however, the hail algorithm results should not be affected because the blocked beam is below the freezing level.
- Does the trainee note the heights of the 0 and -20^{o}C levels and check to see if they are representative of the afternoon conditions? They should be representative for the morning but with the cold pool moving overhead, the heights might be overestimated.
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA algorithm, or does the trainee come up with their own estimate?
- Does the trainee use either the 4-panel or all-tilts loop to watch the height of the intense core? At 1836 UTC, the 55dBZ core extends to 31 kft MSL.
- Does the trainee notice the recurring backbuilding and echo training over the same area by around 1850 UTC?
- Does the trainee utilize the 1 hour and storm total precipitation maps and notice the 1.5-2”/hour rates as estimated by radar?
- Does the trainee use the hi-res topo map to determine if the heavy rainfall is over steep terrain?
- Does the trainee use radar-estimated rainfall in warning products? If so, are the amounts used verbatim, or are the amount modified based on the data analysis?

The Southern Salt Lake County Storm (1730-1945 UTC)

Time (UTC)	Description
1730 GOES-10	South end of -30^{o}C tops.
1734 KMTX	Two elevated 40dBZ cores @ 156^{o} 55 nm. VIL < 20 kg/m^{2}.
1745 GOES-10	Southern end of north-south oval of anvil top. Min CTT= -38^{o}C.
1751 KMTX	Cores consolidated. Ref gradient and small WER at @ 168^{o} 53 nm; 50 dBZ to 22 kft MSL;
1756 KMTX	VIL increased to 25 kg/m^{2}; Cell becomg kidney-shaped; Weak cyc circulation V_r=10kts 22kft MSL.@ 169^{o} 55 nm.
1801 KMTX	Cyc circulation weakened; 55 dBZ to 26.5 kft MSL; Small WER; VIL increased to 30 kg/m^{2}.
1806 KMTX	WER increased in width but 55 dBZ fell to 21 kft MSL;
1812 KMTX	Increased convergence at 0.5^{o} slice just west of notch;
1816 KMTX	missing 2.4-9.9 deg slice. VCP switch to 11. Conv rotation increased to V_r=15 kt in lowest two slices @162^{o} 52 nm.
1821 KMTX	55 dBZ up to 31 kft MSL; WER almost a BWER @160° 51nm on the 2.4°°slice. VIL=35 kg/m^{2};
1826 KMTX	Weak (V_r=20kt) meso lowest 3 slices. 1.5^{o} slice showed the most symmetry; VIL=40 kg/m^{2}; MEHS to 1.5”
1830 GOES-10	CTT min with overshoot = -47^{o}C; Surrounding anvil around -42^{o}C.
1831 KMTX	Meso weakened, no significant circulation. Strong WER continues @158^{o} 51 nm.
1836 KMTX	Lost lowlevel inflow notch in reflectivity; Convergent signature in lowest slice. Weak rotation further aloft (V_r=10kt).
1815 LSR SLC	LSR #1; 1.5” hail in Herriman, Salt Lake CO. Note: the 1800-1815 UTC report was put here because the storm did not reach Harriman until 1815 UTC.
1841 KMTX	55 dBZ still up to 30 kft MSL; OHP shows 1.5” @ 160^{o} 49 nm.
1845 GOES-10	CTT min up to 46^{o}C; Still a well defined overshoot.
1846 KMTX	MEHS down to 1”; New cores forming upstream.

Time (UTC)	Description
1851 KMTX	55 dBZ down to 20 kft MSL; MEHS < 1”; VIL down to 35 kg/m^2;
1901 KMTX	55 dBZ surged up to 30 kft MSL @ 150^o 49 nm;
1911 KMTX	55 dBZ down to 20 kft MSL;
1830-1840 LSR SLC	LSR #2; 3/4” hail in Sandy City, Salt Lake CO. Note: the time does not match the radar data.
1915 GOES-10	CTT min = -46^{o}C. Overshooting top well defined.
1916 KMTX	55 dBZ down to 11 kft MSL; VIL down to 25 kg/m^2; MEHS < 1”. STP shows 2”, likely some hail contamination. OHP~1.5-2”.
1926 KMTX	35 kt DV@ 144^o 52 nm - 1.5^o slice; No time or height continuity. Although there is a small elevated core.
1930 GOES-10	CTT min = -45^{o}C; overshoot is ill-defined.
1945 KMTX	STP at 2” with some overestimation.

Considerations:

- Does the trainee notice the onset of a WER and a sharp reflectivity gradient curved in a concave manner on the storm’s southern flank at 1756 UTC? The reflectivities are still low but the shape of the core suggests a relatively strong updraft.
- Does the trainee notice the increased velocity convergence and circulation in the lowest few slices at 1811 UTC? The values are still weak, but they suggest a strengthening updraft.
- Does the trainee notice the onset of an elevated 55 dBZ core extending up to 26 kft MSL at 1801 UTC?
- Does the trainee analyze the hail size potential of this storm and then compare it to the MEHS in the HDA?
- Does the trainee notice that this storm is accompanied by new upstream cell initiation and cell training is occurring over the area west of Sandy and I-25?
- Does the trainee notice the hourly rainfall amounts in excess of 2 inches west of Sandy and I-25?
- Does the trainee factor in hail contamination, possibility of surface drainage, and terrain if a flash flood warning is considered?

Toole-Davis County Storm (1816-1846 UTC)

Time (UTC)	Description
1816 KMTX	VIL 35 kg/m^2, MEHS 0.75”
1821 KMTX	55 dBZ to 25 Kft AGL, areal increase in 35 kg/m2 VIL, MEHS 1”, POSH and POH 100%, 1.5-2” OHP
1826 KMTX	55 dBZ to 24 Kft AGL, VIL increase to 40kg/m^2; MEHS=1.25”, 60 dBZ first appears at 4 Kft AGL
1830	IR cloud top temperature min -44^{o}C (warmer than storms to the south)
1831 KMTX	55 dBZ to 23 Kft and 40 dbz to 30 Kft
1846 KMTX	reflectivity weakens aloft as storm enters its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over the Great Salt Lake, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Salt Lake-Morgan County Storm (1830-1916)

Time (UTC)	Description
1830	IR cloud top temperature min -47^{o}C
1831 KMTX	50 dBZ to 24 Kft and 45 dBZ to 30 Kft, 60 kt gate-to-gate delta V only at lowest tilt (5 Kft AGL) and in an area of noisy velocity data, well defined divergence aloft (85 kt delta V)
1836 KMTX	50 dBZ to 29 Kft and 45 kBZ to 33 Kft, VIL 30 kg/m^2, MEHS 0.75”, weak mesocyclone-scale rotation (20-25 kts at 36 nmi) forming through a deep layer, weak TDA detection with a 56 knot LLDV

Time (UTC)	Description
1841 KMTX	50 dBZ to 28 Kft and 45 dBZ to 34 Kft, MEHS 1”, POSH and POH 100%, weak TDA detection (50 kt LLDV) continues, velocity data less noisy, rotation increases to moderate strength (30 kt V_r at 38 nmi)
1841-1855 SLC	LSR#3: F2 tornado in Salt Lake City
1845	IR cloud top temperature min -47^{o}C expands
1846 KMTX	55 dBZ to 25 Kft, mesocyclone rotation strengthens to 35 kt V_r, weak TDA detection (58 kt LLDV) continues, VIL increase to 45 kg/m^2; MEHS=1.25”, POSH and POH 100%, large area of 55 dBZ at 5 Kft
1851 KMTX	weak 40 kt gate-to-gate low-level delta-V, rotation weakened through a deep layer
1856 KMTX	1.5-2” OHP
1900 SLC	LSR#4: G52 kts in North Salt Lake
1901 KMTX	VIL increase to 30 kg/m^2 again
1915-1920 SLC	LSR#5: 1.5” hail in Bountiful
1916 KMTX	reflectivity weakens aloft as storm moves over 8 Kft MSL mountains where it begins its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with the high reflectivity cores aloft early in the storm’s lifetime?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee recognize the noisy velocity data over downtown Salt Lake City at the lowest elevation angle, and therefore put less faith in the velocity data prior to 1841?
- Does the trainee recognize the development of organized weak rotation at 1836 UTC?
- Does the trainee utilize the TDA in their analysis? If not, does the trainee recognize the weak-moderate TVS signatures in the base data?
- Does the trainee recognize the increased rotation during the 1841 and 1846 volume scans gives more credence to the tornado threat?

- Does the trainee cancel the warning prematurely when the radar signature weakens?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee anticipate the threat to diminish when the storm moves east of Salt Lake City into the mountains?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Western Toole County Storm (1921-1950 UTC)

Time (UTC)	Description
1921 KMTX	55 dBZ to 26 Kft, VIL 35 kg/m^2, MEHS 1”
1926 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft AGL, VIL 40 kg/m2, MEHS 1”, POSH and POH 100%
1930	IR cloud top temperature min -43^{o}C
1931 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft, VIL increase to 45 kg/m^2; MEHS=1.25”, 60 dBZ first appears at 18 Kft AGL
1935 KMTX	60 dBZ to 25 Kft AGL, 45 dBZ to 35 Kft AGL, deep 60 dBZ core, area increase in 45 kg/m^2 VIL; MEHS=1.75”,
1940 KMTX	55 dBZ to 25 Kft AGL, 45 kg/m^2 VIL; MEHS=1.25”
1945 KMTX	50 dBZ to 25 Kft AGL, 40 kg/m^2 VIL; MEHS=1.5”
1945	IR cloud top temperature min -43^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?

- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Davis County Storm (1921-2000 UTC)

Time (UTC)	Description
1916 KMTX	1.5” OHP estimate
1921 KMTX	50 dBZ to 25 Kft, VIL 30 kg/m^2, MEHS 0.75”
1926 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m2, MEHS 0.75”
1930	IR cloud top temperature min -47^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL increase to 35 kg/m^2; MEHS=1”
1935 KMTX	35 kg/m^2 VIL;
1940 KMTX	35 kg/m^2 VIL; MEHS=1”
1945 KMTX	40 kg/m^2 VIL; MEHS=1”
1945	larger area of -47^{o}C IR cloud top temperature min
1955 KMTX	30 kg/m^2 VIL; MEHS=0.75”
2000 KMTX	55 dBZ to 27 Kft, 30 kg/m^2 VIL; MEHS=0.75”

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Eastern Morgan-Rich County Storm (1931-1950 UTC)

Time (UTC)	Description
1930	IR cloud top temperature min -46^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m^2; MEHS=1”, POSH and POH 100%
1935 KMTX	40 kg/m^2 VIL, MEHS 1.25”, POSH and POH 100%
1940 KMTX	60 dBZ core from 11-22 Kft, 40 kg/m^2 VIL; MEHS=1.5”,POSH and POH 100%
1945 KMTX	40 kg/m^2 VIL; MEHS=1”,POSH and POH 100%
1945	IR cloud top temperature min -45^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Northeastern Toole County Storm (1931-2000 UTC)

Time (UTC)	Description
1931 KMTX	50 dBZ to 26 Kft AGL, VIL 30 kg/m^2; MEHS=0.75”
1935 KMTX	35 kg/m^2 VIL, MEHS 0.75”
1940 KMTX	VIL weakens to 25 kg/m^2, MEHS 0.75
1945 KMTX	MEHS=0.75”

Time (UTC)	Description
1950 KMTX	large area of 55-60 dBZ reflectivities at 5 Kft, 50 dBZ to 24 Kft, MEHS 0.75
1955 KMTX	50 dBZ to 25 Kft, 30 kg/m^2 VIL, MEHS 0.75”
2000 KMTX	50 dBZ to 27 Kft, 40 kg/m^2 VIL, MEHS 1”, POSH and POH 100%, 1.5” OHP estimate

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

4: Interval Based Simulation

I. Introduction

This simulation allows the trainee to develop critical thinking skills. To that end, the trainer and trainee should come to consensus through discussion when arriving at decision points.

The simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing numerous storms, one of which produces a significant tornado (F2 damage) in downtown Salt Lake City, and others that produce severe hail. At various points in the simulation, the WES trainer will pause the simulation and query the trainee about specific learning points. The trainer and trainee should discuss decisions based on the available information and expected outcomes. This simulation is appropriate for a warning forecaster who is proficient at issuing warnings and can benefit from practicing handling conflicting information and challenging warning workloads. To get the most out of this simuation, the trainer should consider **not** giving the tornado report as a spotter report during this simulation.

Objectives

The training objectives of this interval-based simulation are:

- Demonstrate effective methods of data interpretation.
- Demonstrate proper type and content of warnings.
- Demonstrate how to weigh information and handle uncertainty in the warning decision making process.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, pause the simulation and discuss important learning issues, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This interval-based simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for simulation discussion, and 30 minutes for the post-brief. The simulation starts at 1745 UTC on August 11th, 1999 and ends at 1945 UTC on August 11th, 1999. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sectors.
2. Print out the warning log from Support Materials (see page C-2) so the trainee can keep track of the warnings they issue.
3. Print out the mesonet plot from Support Materials (see page C-4) so the trainee can see the latest high-resolution surface data.
4. Close down any existing D2D sessions, and start the simulator for the time period 1745 UTC on August 11th, 1999 to 1945 UTC on August 11th, 1999.
5. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.
6. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the SLC CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.
7. Instruct the trainee to:
   - Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA,
   - Evaluate warning sectorization issues.
   - Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
8. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:
   - Eta forecast sounding for SLC at 18 UTC contains ~ 1240 j/kg of surface based CAPE (SBCAPE) and ~ 25 kts of sfc-400 mb shear.
   - Surface dewpoints at 17 UTC in the low 50°Fs with patches of low- and midlevel clouds indicative of relatively high values of boundary layer moisture.
   - Morning thunderstorms in southern ID indicate atmosphere is convectively unstable.
   - Upper-tropospheric trough with a significant cold pool centered over NV at 12 UTC is moving over the CWA. The leading edge of the cold pool is marked by the leading edge of colder brightness temperatures in the GOES-10 water vapor imagery. That leading edge reaches the Salt Lake Valley by 16 UTC.

- The morning Skew-T at SLC modified with the 17 UTC SLC observation (74/50) yields a SBCAPE of 830 j/kg with a significant amount of instability in lower levels (0-3 km). Further modifying the SLC conditions with mid and upper-tropospheric temperatures within the cold pool as sampled by the Elko, NV sounding, reveals an SBCAPE of 1800 j/kg.
- There is no CIN with a surface T=74^{o}F and Td=50^{o}F at SLC with either the SLC or the EKO mid and upper-level tropospheric temperatures.
- 0-6 km shear from the RUC80 model (calculated by the volume browser in CONUS scale) is weak because of highly veered boundary-layer flow, and the 500 mb flow used in the 6 km approximation is not representative of the 6km AGL layer. The shear weakens throughout the day as the cold core moves closer. Using the volume browser to subtract the surface from 400 mb winds yields slightly higher shear from 25-30 kts. However, the surface winds analyzed by the RUC80 are too veered relative to the observations. Although the VWP from KMTX also shows similar winds at 400 mb compared to the RUC (225^{o} 25kt), stronger winds are suggested by LAPS just to the south of the Great Salt Lake. The LAPS analysis at 17 UTC shows 40 kt winds at 400 mb to the south of the Great Salt Lake (in the warning area) and southerlies at the surface.
- Near surface winds of 180^{o} at 14 kts found in the 17 UTC SLC metar, and southwest winds of 35-40 kts at 400 mb in the 17 UTC LAPS over SLC, yields an approximate 0-6 km shear of 30-35 kts. This is at the lower margins for expecting organized supercells, even with the more liberal shear-estimate. Typical supercell values would be around 40 kts and higher. Note that 400 mb is used to approximate the 6 km layer above ground.
- Southerly (15 kt) valley floor winds (4 Kft MSL) and the 245^{o} 15kt at 8 Kft MSL combine to make low-level (0-1 km) shear values of about 10 - 15 kts. The weak shear and low 0-1 km SRH indicate a low chance of supercell tornadoes without local modification of the environment.
- 17 UTC dewpoint depressions are running from 20 - 24^{o}F (with higher values expected as heating continues) yielding mixed LCL heights around 1500 m, which is above those values associated with 95% of significant (> F1) tornadoes.
- Steep lapse rates, no CIN, and potentially 1800 j/kg SBCAPE in the presence of 25-35 kt shear indicate the potential for moderately strong updrafts. Although shear is marginal for supercells, should any occur, the potential for larger size hail will be higher. In addition, the wetbulb-zero heights around 7.2 kft AGL and dry air in the boundary layer indicate limited melting of any hailstones.

- Severe downbursts are possible given the 20-24^{o}F surface dewpoint depressions (higher values expected with more heating) and estimated CAPE. Lateral dry air entrainment may be limited owing to moist air at midlevels. Surface to 550mb theta-E depressions are small (10-15K), indicating limited potential for downdraft forcing from lateral dry air entrainment.
- This environment is not significantly moist such as in a true monsoonal pattern. However, given the estimated CAPEs and the potential for cell training over steep terrain with sufficiently low LCLs, some flash flooding is possible.
- Convection initiation sources include areas of high terrain intersecting locally enhanced regions of low- and midlevel moisture. Other initiation sources include a northeast-southwest oriented boundary lying just south of the Great Salt Lake at 17 UTC as observed by several mesonet stations. The origins of the boundary may be a lake breeze or another source, such as from previous convection.

9. Discuss the warning sector issues, and have the trainee warn for the SLC CWA covered by the KMTX radar. The trainer may wish to adjust the warning sector based on the skill of the trainee (e.g. consider creating a warning sector containing the storms in the central part of the CWA. If the CWA is sectorized, the trainee should adjust the focus of the discussion points accordingly).

10. Inform the trainee that the flash flood guidance for the SLC CWA is approximately 1.5” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in an area of general thunder, and no watch is in effect.

III. Simulation

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. This simulation starts at 1745 UTC on August 11th, 1999 and ends at 1945 UTC on August 11th, 1999. At three times during the simulation (1826, 1845, 1940 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's warnings and methodology. Discussion is encouraged. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 4-8.

Trainer Tasks

1. Explain the objectives to the trainee (see page 4-1).

2. State to the trainee that:

- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the two hour simulation, at which times the trainer will query the trainee about their warnings and their methodology.
- If new warning sectors are defined, the trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing warning sectors.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 1745 UTC on August 11th, 1999 to 1945 UTC on August 11th, 1999. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.
- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

5. Give the trainee 5-10 minutes to set up their D2D sessions.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide (consult Appendix A for graphical locations).

7. At 1826 UTC pause the simulation for up to 10 minutes and ask:

(1) “What are the current warnings out and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

Get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Discuss the reasoning with the trainee and try to reach a consensus on the warning decision. Some considerations for discussion points include:

- the severe hail/wind threat for the storms in southern Salt Lake and northeast Box Elder Counties,
- product choice,
- warning composition details,
- radar sampling issues,
- environmental analysis, and
- uncertainty in the decision making process.

8. Resume simulation. Clear and reload any images loaded during the pause.

9. At 1845 UTC pause the simulation for up to 10 minutes and repeat **Step 7**. At this time pay particular attention to the rotation in northern Salt Lake County.

10. Resume simulation. Clear and reload any images loaded during the pause.

11. At 1940 UTC pause the simulation for up to 10 minutes and repeat **Step 7**. At this time pay particular attention to the severe hail/wind threat for the storms in western Toole and eastern Morgan Counties and the more marginal severe threat in Cache, Davis, and northeastern Toole Counties.

12. End the simulation, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objectives of the post simulation briefing are to summarize the successes and failures of the warning process, and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Recognizing a rapidly evolving mesocyclone and tornado.

- The difficulty of perceiving and comprehending the cues in the data associated with the development of unanticipated events.
- Sampling limitations of radar and other warning inputs.
- Maintaining a high level of situation awareness throughout.
- Optimal usage of base data analysis with radar derived products and algorithms.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:
  - Discuss the strengths and weaknesses of the data used in the decision making as well as the approach to analyzing the data.
  - Discuss any problems encountered with determining the type or content of the warnings.
  - Discuss the challenges of synthesizing the warning inputs and the sources of uncertainty.

2. Review the reports and the times to compare to the warnings.

3. Consider reviewing the TDWR data to discuss radar sampling issues using the following website:
http://www.wdtb.noaa.gov/resources/tutorials/11aug99/summary.htm

4. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. Part of the evaluation can be done during the query sessions in the simulation, and more evaluation can be done while the trainee is actively involved in the warning operations during the simulation. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1700-2005 KMTX	radar data time period

Considerations

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, or MSAS/LAPS)?
- Does the trainee recognize that objective analysis fields are more problematic in mountainous regions due to terrain effects and the lack of observations?

Storm Summary

During the simulation there are four areas of thunderstorm activity covered by the KMTX radar that require monitoring for severe weather in the CWA. The first area of deep convection to monitor is over northeastern Box Elder County around 1756 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail and heavy rainfall.

The second area to monitor is in the central part of the CWA in the Salt Lake City area from 1800-2000 UTC. Numerous thunderstorms occur over this area, two of which produce significant severe weather. The first strong storm exhibits some marginal supercell characteristics in southern Salt Lake County, where it produces 0.75-1.5” hail.

Just to the north of the intense storm in southern Salt Lake County, another cluster of cells develops on a boundary just south of the Great Salt Lake. A rotating updraft (captured on video) develops from these cells acting on the boundary, where a weak to moderate strength mesocyclone, with weak-moderate gate-gate shears, develops upward from the shear axis on the boundary, displayed well in non-operational radar data sets (TDWR). The radar depiction of rotation is hampered by the noisy velocity data around the area where the tornado develops, the long range from the radar, and the high beam height at 0.5 degrees due to the elevated radar location. A tornado develops with this storm as it moves through downtown Salt Lake City, producing primarily F1 damage with some F2 damage. One fatality and 80 injuries occurred with the tornado. The storm also produces wind gusts to 52 kts and hail to 1.5”. Numerous other storms with marginal severe hail signatures develop in the area of the Salt Lake City storm, though no severe weather is reported with the weaker storms.

A third area of convection to monitor occurs in easter Morgan County around 1921 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

A fourth area of convection to monitor occurs in easter Morgan County around 1931 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

Northeastern Box Elder and extreme Northwestern Cache County Multicell (1730-1945)

Time (UTC)	Description
1730 GOES-10	Isolated anvil with -38^{o}C CTT minimum.
1734 KMTX	55dBZ to 15.7kft and 50dBZ to 25 kft MSL@ 353^{o} 33 nm; Two adj cells; VIL < 30 kg/m^{2}. Weak midlevel conv N. cell.
1740 KMTX	55 dBZ to 21 kft MSL @ 357^{o} 31 nm; VIL < 30 kg/m^{2}; MEHS< 1”
1745 GOES-10	CTT min dropped to -42^{o}C.
1746 KMTX	55 dBZ to 24 kft MSL @ 357^{o} 37 nm with the northern cell.
1751 KMTX	VIL increased to 30 kg/m^{2} in northern cell.
1756 KMTX	VIL increased to 35 kg/m^{2} in middle cell; New cell dvlped in S. flank @359^{o} 31 nm; MEHS = 1” in middle cell.
1801 KMTX	VIL increased to 40 kg/m^{2} in northern end(357^{o} 40 nm). MEHS < 1”; Southern cell has 60 dBZ to 22 kft MSL (359^{o} 31 nm).
1806 KMTX	VIL down to 35 but MEHS up to 1”

Time (UTC)	Description
1811 KMTX	OHP shows 1” at 357^o 37 nm; Area is on I-84.
1816 KMTX	Missing 2.4-9.9 deg slices. VIL increased to 40 kg/m^2
1826 KMTX	VIL remains at 40 kg/m^2 @ 008^o 34 nm.
1830 GOES-10	CTT min =-47^{o}C; A well defined overshoot.
1836 KMTX	55 dBZ up to 30 kft @ 010^o 34 nm;
1841 KMTX	OHP shows 1.5” @ 011^o 36 nm;
1845 GOES-10	CTT min up to -46^{o}C; Overshoot.becomes poorly defined.
1846 KMTX	New cell forming on south flank; VIL up to 45 kg/m^2.
1851 KMTX	New cell becmg dominant at 011^o 32 nm; 55 dBZ up to 28 kft.; VIL=35 kg/m^2.
1856 KMTX	WER on east and west flanks of new cell; OHP shows 2”.
1901 KMTX	VIL down to 30 kg/m^2;
1911 KMTX	STP up to 3”; Psbl hail contamination; 55 dBZ down to 13 kft MSL.
1915 GOES-10	No well defined CTT min; Overhead anvil around -44^{o}C.
1916 KMTX	VIL down to 25 kg/m^2; 55 dBZ only to 10 kft MSL; MEHS < 1”.
1930 GOES-10	New cell in N. Cache CO has CTT min = -48^{o}C; No well defined min for cells in far NE Box Elder CO.
1931 KMTX	VIL up to 30 kg/m^2 @ 49^o 31 nm; Cell has elevated core and is east of previous core in NW Cache CO. Western cell VIL still 25.
1935 KMTX	Eastern cell 55 dBZ up to 20 kft.
1945 KMTX	OHP decreasing in NE BoxElder CO @014^o 37 nm. STP steady at 3”, likely with minor overestimation.
1945 GOES-10	CTT min with N. Cache CO. storm = -48^{o}C; No other CTT min nearby.

Considerations:

- By 1746 UTC, does the trainee understand the reason behind the low reflectivities in the lowest slice? The trainee should recognize that beam blockage is the cause.

- Does the trainee anticipate how the beam blockage may affect the VIL and hail algorithm results? The VIL may be decreased by 10-20%, however, the hail algorithm results should not be affected because the blocked beam is below the freezing level.
- Does the trainee note the heights of the 0 and -20^{o}C levels and check to see if they are representative of the afternoon conditions? They should be representative for the morning but with the cold pool moving overhead, the heights might be overestimated.
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA algorithm, or does the trainee come up with their own estimate?
- Does the trainee use either the 4-panel or all-tilts loop to watch the height of the intense core? At 1836 UTC, the 55dBZ core extends to 31 kft MSL.
- Does the trainee notice the recurring backbuilding and echo training over the same area by around 1850 UTC?
- Does the trainee utilize the 1 hour and storm total precipitation maps and notice the 1.5-2”/hour rates as estimated by radar?
- Does the trainee use the hi-res topo map to determine if the heavy rainfall is over steep terrain?
- Does the trainee use radar-estimated rainfall in warning products? If so, are the amounts used verbatim, or are the amount modified based on the data analysis?

The Southern Salt Lake County Storm (1730-1945 UTC)

Time (UTC)	Description
1730 GOES-10	South end of -30^{o}C tops.
1734 KMTX	Two elevated 40dBZ cores @ 156^{o} 55 nm. VIL < 20 kg/m^{2}.
1745 GOES-10	Southern end of north-south oval of anvil top. Min CTT= -38^{o}C.
1751 KMTX	Cores consolidated. Ref gradient and small WER at @ 168^{o} 53 nm; 50 dBZ to 22 kft MSL;
1756 KMTX	VIL increased to 25 kg/m^{2}; Cell becomg kidney-shaped; Weak cyc circulation V_r=10kts 22kft MSL.@ 169^{o} 55 nm.

Time (UTC)	Description
1801 KMTX	Cyc circulation weakened; 55 dBZ to 26.5 kft MSL; Small WER; VIL increased to 30 kg/m^2.
1806 KMTX	WER increased in width but 55 dBZ fell to 21 kft MSL;
1812 KMTX	Increased convergence at 0.5^o slice just west of notch;
1816 KMTX	missing 2.4-9.9 deg slice. VCP switch to 11. Conv rotation increased to V_r=15 kt in lowest two slices @162^o 52 nm.
1821 KMTX	55 dBZ up to 31 kft MSL; WER almost a BWER @160° 51nm on the 2.4°°slice. VIL=35 kg/m^2;
1826 KMTX	Weak (V_r=20kt) meso lowest 3 slices. 1.5^o slice showed the most symmetry; VIL=40 kg/m^2; MEHS to 1.5”
1830 GOES-10	CTT min with overshoot = -47^{o}C; Surrounding anvil around -42^{o}C.
1831 KMTX	Meso weakened, no significant circulation. Strong WER continues @158^o 51 nm.
1836 KMTX	Lost lowlevel inflow notch in reflectivity; Convergent signature in lowest slice. Weak rotation further aloft (V_r=10kt).
1815 LSR SLC	LSR #1; 1.5” hail in Herriman, Salt Lake CO. Note: the 1800-1815 UTC report was put here because the storm did not reach Harriman until 1815 UTC.
1841 KMTX	55 dBZ still up to 30 kft MSL; OHP shows 1.5” @ 160^o 49 nm.
1845 GOES-10	CTT min up to 46^{o}C; Still a well defined overshoot.
1846 KMTX	MEHS down to 1”; New cores forming upstream.
1851 KMTX	55 dBZ down to 20 kft MSL; MEHS < 1”; VIL down to 35 kg/m^2;
1901 KMTX	55 dBZ surged up to 30 kft MSL @ 150^o 49 nm;
1911 KMTX	55 dBZ down to 20 kft MSL;
1830-1840 LSR SLC	LSR #2; 3/4” hail in Sandy City, Salt Lake CO. Note: the time does not match the radar data.
1915 GOES-10	CTT min = -46^{o}C. Overshooting top well defined.
1916 KMTX	55 dBZ down to 11 kft MSL; VIL down to 25 kg/m^2; MEHS < 1”. STP shows 2”, likely some hail contamination. OHP~1.5-2”.

Time (UTC)	Description
1926 KMTX	35 kt DV@ 144^o 52 nm - 1.5^o slice; No time or height continuity. Although there is a small elevated core.
1930 GOES-10	CTT min = -45^{o}C; overshoot is ill-defined.
1945 KMTX	STP at 2” with some overestimation.

Considerations:

- Does the trainee notice the onset of a WER and a sharp reflectivity gradient curved in a concave manner on the storm’s southern flank at 1756 UTC? The reflectivities are still low but the shape of the core suggests a relatively strong updraft.
- Does the trainee notice the increased velocity convergence and circulation in the lowest few slices at 1811 UTC? The values are still weak, but they suggest a strengthening updraft.
- Does the trainee notice the onset of an elevated 55 dBZ core extending up to 26 kft MSL at 1801 UTC?
- Does the trainee analyze the hail size potential of this storm and then compare it to the MEHS in the HDA?
- Does the trainee notice that this storm is accompanied by new upstream cell initiation and cell training is occurring over the area west of Sandy and I-25?
- Does the trainee notice the hourly rainfall amounts in excess of 2 inches west of Sandy and I-25?
- Does the trainee factor in hail contamination, possibility of surface drainage, and terrain if a flash flood warning is considered?

Toole-Davis County Storm (1816-1846 UTC)

Time (UTC)	Description
1816 KMTX	VIL 35 kg/m^2, MEHS 0.75”
1821 KMTX	55 dBZ to 25 Kft AGL, areal increase in 35 kg/m2 VIL, MEHS 1”, POSH and POH 100%, 1.5-2” OHP
1826 KMTX	55 dBZ to 24 Kft AGL, VIL increase to 40kg/m^2; MEHS=1.25”, 60 dBZ first appears at 4 Kft AGL

Time (UTC)	Description
1830	IR cloud top temperature min -44^{o}C (warmer than storms to the south)
1831 KMTX	55 dBZ to 23 Kft and 40 dbz to 30 Kft
1846 KMTX	reflectivity weakens aloft as storm enters its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over the Great Salt Lake, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Salt Lake-Morgan County Storm (1830-1916)

Time (UTC)	Description
1830	IR cloud top temperature min -47^{o}C
1831 KMTX	50 dBZ to 24 Kft and 45 dBZ to 30 Kft, 60 kt gate-to-gate delta V only at lowest tilt (5 Kft AGL) and in an area of noisy velocity data, well defined divergence aloft (85 kt delta V)
1836 KMTX	50 dBZ to 29 Kft and 45 kBZ to 33 Kft, VIL 30 kg/m^2, MEHS 0.75”, weak mesocyclone-scale rotation (20-25 kts at 36 nmi) forming through a deep layer, weak TDA detection with a 56 knot LLDV
1841 KMTX	50 dBZ to 28 Kft and 45 dBZ to 34 Kft, MEHS 1”, POSH and POH 100%, weak TDA detection (50 kt LLDV) continues, velocity data less noisy, rotation increases to moderate strength (30 kt V_r at 38 nmi)
1841-1855 SLC	LSR#3: F2 tornado in Salt Lake City
1845	IR cloud top temperature min -47^{o}C expands

Time (UTC)	Description
1846 KMTX	55 dBZ to 25 Kft, mesocyclone rotation strengthens to 35 kt V_r, weak TDA detection (58 kt LLDV) continues, VIL increase to 45 kg/m^2; MEHS=1.25”, POSH and POH 100%, large area of 55 dBZ at 5 Kft
1851 KMTX	weak 40 kt gate-to-gate low-level delta-V, rotation weakened through a deep layer
1856 KMTX	1.5-2” OHP
1900 SLC	LSR#4: G52 kts in North Salt Lake
1901 KMTX	VIL increase to 30 kg/m^2 again
1915-1920 SLC	LSR#5: 1.5” hail in Bountiful
1916 KMTX	reflectivity weakens aloft as storm moves over 8 Kft MSL mountains where it begins its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with the high reflectivity cores aloft early in the storm’s lifetime?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee recognize the noisy velocity data over downtown Salt Lake City at the lowest elevation angle, and therefore put less faith in the velocity data prior to 1841?
- Does the trainee recognize the development of organized weak rotation at 1836 UTC?
- Does the trainee utilize the TDA in their analysis? If not, does the trainee recognize the weak-moderate TVS signatures in the base data?
- Does the trainee recognize the increased rotation during the 1841 and 1846 volume scans gives more credence to the tornado threat?
- Does the trainee cancel the warning prematurely when the radar signature weakens?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?

- Does the trainee anticipate the threat to diminish when the storm moves east of Salt Lake City into the mountains?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Western Toole County Storm (1921-1950 UTC)

Time (UTC)	Description
1921 KMTX	55 dBZ to 26 Kft, VIL 35 kg/m^2, MEHS 1”
1926 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft AGL, VIL 40 kg/m2, MEHS 1”, POSH and POH 100%
1930	IR cloud top temperature min -43^{o}C
1931 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft, VIL increase to 45 kg/m^2; MEHS=1.25”, 60 dBZ first appears at 18 Kft AGL
1935 KMTX	60 dBZ to 25 Kft AGL, 45 dBZ to 35 Kft AGL, deep 60 dBZ core, area increase in 45 kg/m^2 VIL; MEHS=1.75”,
1940 KMTX	55 dBZ to 25 Kft AGL, 45 kg/m^2 VIL; MEHS=1.25”
1945 KMTX	50 dBZ to 25 Kft AGL, 40 kg/m^2 VIL; MEHS=1.5”
1945	IR cloud top temperature min -43^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Davis County Storm (1921-2000 UTC)

Time (UTC)	Description
1916 KMTX	1.5” OHP estimate
1921 KMTX	50 dBZ to 25 Kft, VIL 30 kg/m^2, MEHS 0.75”
1926 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m2, MEHS 0.75”
1930	IR cloud top temperature min -47^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL increase to 35 kg/m^2; MEHS=1”
1935 KMTX	35 kg/m^2 VIL;
1940 KMTX	35 kg/m^2 VIL; MEHS=1”
1945 KMTX	40 kg/m^2 VIL; MEHS=1”
1945	larger area of -47^{o}C IR cloud top temperature min
1955 KMTX	30 kg/m^2 VIL; MEHS=0.75”
2000 KMTX	55 dBZ to 27 Kft, 30 kg/m^2 VIL; MEHS=0.75”

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Eastern Morgan-Rich County Storm (1931-1950 UTC)

Time (UTC)	Description
1930	IR cloud top temperature min -46^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m^2; MEHS=1”, POSH and POH 100%

Time (UTC)	Description
1935 KMTX	40 kg/m^2 VIL, MEHS 1.25”, POSH and POH 100%
1940 KMTX	60 dBZ core from 11-22 Kft, 40 kg/m^2 VIL; MEHS=1.5”,POSH and POH 100%
1945 KMTX	40 kg/m^2 VIL; MEHS=1”,POSH and POH 100%
1945	IR cloud top temperature min -45^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Northeastern Toole County Storm (1931-2000 UTC)

Time (UTC)	Description
1931 KMTX	50 dBZ to 26 Kft AGL, VIL 30 kg/m^2; MEHS=0.75”
1935 KMTX	35 kg/m^2 VIL, MEHS 0.75”
1940 KMTX	VIL weakens to 25 kg/m^2, MEHS 0.75
1945 KMTX	MEHS=0.75”
1950 KMTX	large area of 55-60 dBZ reflectivities at 5 Kft, 50 dBZ to 24 Kft, MEHS 0.75
1955 KMTX	50 dBZ to 25 Kft, 30 kg/m^2 VIL, MEHS 0.75”
2000 KMTX	50 dBZ to 27 Kft, 40 kg/m^2 VIL, MEHS 1”, POSH and POH 100%, 1.5” OHP estimate

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

5: Virtual Reality Simulation

I. Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a CWA containing numerous storms, one of which produces a significant tornado (F2 damage) in downtown Salt Lake City, and others that produce severe hail. This simulation is appropriate for an experienced warning forecaster who is proficient with the mechanics of issuing warnings and can benefit from practicing warning workload management. To get the most out of this simuation, the trainer should consider **not** giving the tornado report as a spotter report during this simulation.

Objective

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Trainer Evaluation Guide), and V (Post-simulation Briefing) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate the severe weather threat for the CWA, and issue warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing, and discuss sectorizing isues for this event.

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject information such as spotter reports, special forecast requests, and any type of challenges that can happen in a real event (be creative!).

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This virtual reality simulation is designed to take 3.25 hours to complete, with 30 minutes for the pre-simulation briefing, 2.25 hours for the simulation, and 30 minutes for the post-brief. The simulation starts at 1745 UTC on August 11th, 1999 and ends at 2000 UTC on August 11th, 1999. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-2) so the trainee can keep track of the warnings they issue.

3. Print out the mesonet plot from Support Materials (see page C-4) so the trainee can see the latest high-resolution surface data.

4. Close down any existing D2D sessions, and start the simulator for the time period 1745 UTC on August 11th, 1999 to 2000 UTC on August 11th, 1999.

5. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

6. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the SLC CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

7. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
- Evaluate warning sectorization issues.
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

8. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- Eta forecast sounding for SLC at 18 UTC contains ~ 1240 j/kg of surface based CAPE (SBCAPE) and ~ 25 kts of sfc-400 mb shear.
- Surface dewpoints at 17 UTC in the low 50°Fs with patches of low- and midlevel clouds indicative of relatively high values of boundary layer moisture.
- Morning thunderstorms in southern ID indicate atmosphere is convectively unstable.
- Upper-tropospheric trough with a significant cold pool centered over NV at 12 UTC is moving over the CWA. The leading edge of the cold pool is marked by the leading edge of colder brightness temperatures in the GOES-10 water vapor imagery. That leading edge reaches the Salt Lake Valley by 16 UTC.
- The morning Skew-T at SLC modified with the 17 UTC SLC observation (74/50) yields a SBCAPE of 830 j/kg with a significant amount of instability in lower levels (0-3 km). Further modifying the SLC conditions with mid and upper-tropospheric temperatures within the cold pool as sampled by the Elko, NV sounding, reveals an SBCAPE of 1800 j/kg.
- There is no CIN with a surface T=74^{o}F and Td=50^{o}F at SLC with either the SLC or the EKO mid and upper-level tropospheric temperatures.
- 0-6 km shear from the RUC80 model (calculated by the volume browser in CONUS scale) is weak because of highly veered boundary-layer flow, and the 500 mb flow used in the 6 km approximation is not representative of

the 6km AGL layer. The shear weakens throughout the day as the cold core moves closer. Using the volume browser to subtract the surface from 400 mb winds yields slightly higher shear from 25-30 kts. However, the surface winds analyzed by the RUC80 are too veered relative to the observations. Although the VWP from KMTX also shows similar winds at 400 mb compared to the RUC (225^o 25kt), stronger winds are suggested by LAPS just to the south of the Great Salt Lake. The LAPS analysis at 17 UTC shows 40 kt winds at 400 mb to the south of the Great Salt Lake (in the warning area) and southerlies at the surface.

- Near surface winds of 180^o at 14 kts found in the 17 UTC SLC metar, and southwest winds of 35-40 kts at 400 mb in the 17 UTC LAPS over SLC, yields an approximate 0-6 km shear of 30-35 kts. This is at the lower margins for expecting organized supercells, even with the more liberal shear-estimate. Typical supercell values would be around 40 kts and higher. Note that 400 mb is used to approximate the 6 km layer above ground.
- Southerly (15 kt) valley floor winds (4 Kft MSL) and the 245^o 15kt at 8 Kft MSL combine to make low-level (0-1 km) shear values of about 10 - 15 kts. The weak shear and low 0-1 km SRH indicate a low chance of supercell tornadoes without local modification of the environment.
- 17 UTC dewpoint depressions are running from 20 - 24^{o}F (with higher values expected as heating continues) yielding mixed LCL heights around 1500 m, which is above those values associated with 95% of significant (> F1) tornadoes.
- Steep lapse rates, no CIN, and potentially 1800 j/kg SBCAPE in the presence of 25-35 kt shear indicate the potential for moderately strong updrafts. Although shear is marginal for supercells, should any occur, the potential for larger size hail will be higher. In addition, the wetbulb-zero heights around 7.2 kft AGL and dry air in the boundary layer indicate limited melting of any hailstones.
- Severe downbursts are possible given the 20-24^{o}F surface dewpoint depressions (higher values expected with more heating) and estimated CAPE. Lateral dry air entrainment may be limited owing to moist air at midlevels. Surface to 550mb theta-E depressions are small (10-15K), indicating limited potential for downdraft forcing from lateral dry air entrainment.
- This environment is not significantly moist such as in a true monsoonal pattern. However, given the estimated CAPEs and the potential for cell training over steep terrain with sufficiently low LCLs, some flash flooding is possible.

- Convection initiation sources include areas of high terrain intersecting locally enhanced regions of low- and midlevel moisture. Other initiation sources include a northeast-southwest oriented boundary lying just south of the Great Salt Lake at 17 UTC as observed by several mesonet stations. The origins of the boundary may be a lake breeze or another source, such as from previous convection.

9. Discuss the warning sector issues, and have the trainee warn for the SLC CWA covered by the KMTX radar. The trainer may wish to adjust the warning sector based on the skill of the trainee (eg. consider creating a warning sector containing the storms in the central part of the CWA. If the CWA is sectorized, the trainee should adjust the simulation accordingly).

10. Inform the trainee that the flash flood guidance for the SLC CWA is approximately 1.5” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in an area of general thunder, and no watch is in effect.

III. Simulation

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. This 2.25 hour simulation starts at 1745 UTC on August 11th, 1999, and ends at 2000 UTC on August 11th, 1999. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 5-8.

Trainer Tasks

1. State to the trainee:

- The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.
- The trainee will be responsible for interrogating the severe weather threat and creating warnings and follow on statements.
- There will be no pauses during the 2.25 hour simulation (plan accordingly).
- If new warning sectors are defined, the trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing warning sectors.

- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 1745 UTC on August 11th, 1999 to 2000 UTC on August 11th, 1999. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.
- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in Appendix A or the Trainer Evaluation Guide on page 5-8 (consult image in Appendix A for graphical locations), and make up conflicting spotter reports during the simulation to determine if the trainee is evaluating the reports well. Any other incoming calls or distractions should be interjected as to simulate a real environment. This could include briefings to EMS, toxic spills, failure for a warning to transmit, etc.

6. At 1810 UTC consider giving a distracting request. Salt Lake City is hosting a boating event over the Great Salt Lake today, and the City Manager would like a detailed forecast for the Lake over the next few hours. Evaluate the trainee’s ability to effectively answer the request in a timely manner, including whether the response mentions all potential severe weather threats.

7. At 1835 UTC consider disrupting the warning operations. Simulate a D2D crash or spontaneous logout. ***Do not stop the simulator.*** Either have the trainee exit and restart D2D, or have the trainee stop using D2D temporarily and explain how they would recover. Evaluate the trainee’s ability to recover from the disruption.

8. At 1851 UTC consider giving a distracting request. The Salt Lake County emergency manager has called, and he wants to know if the tornado threat is over and if he should stop sounding the tornado sirens for the area. Evaluate the trainee’s ability to effectively answer the request in a timely manner.

9. At 1918 UTC consider disrupting the warning operations. Heavy rain has caused a truck containing hazardous materials to overturn on I-15, about 10-15 miles north of the I-15/I84 intersection in northeast Box Elder County.

Cleanup crews would like a detailed forecast of precipitation and wind over the next 1-2 hours. Evaluate the trainee's ability to effectively answer the request in a timely manner.

10. At 1951 UTC consider giving a false report. A tornado has been reported from Toole in northeastern Toole County. Evaluate the trainee's ability to evaluate the credibility of the report.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Handling stress and workload so as to keep the effective flow of information going.
- Off-loading tasks as necessary.
- Maintaining the big picture issues while periodically focussing on the details.
- Maintaining a high level of situation awareness throughout.
- Recognizing a rapidly evolving mesocyclone and tornado.
- Handling multiple warnings in large counties and in areas with both high and low population density.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:

- Discuss challenges in managing the warning workload.

- Discuss any problems encountered with responding to the disruptions in the warning environment.

2. Review the reports and the times to compare to the warnings.
3. Consider reviewing the TDWR data to discuss radar sampling issues using the following website:
http://www.wdtb.noaa.gov/resources/tutorials/11aug99/summary.htm
4. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation.

General Issues

Time (UTC)	Description
1700-2005 KMTX	radar data time period

Considerations

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, or MSAS/LAPS)?

- Does the trainee recognize that objective analysis fields are more problematic in mountainous regions due to terrain effects and the lack of observations?

Storm Summary

During the simulation there are four areas of thunderstorm activity covered by the KMTX radar that require monitoring for severe weather in the CWA. The first area of deep convection to monitor is over northeastern Box Elder County around 1756 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail and heavy rainfall.

The second area to monitor is in the central part of the CWA in the Salt Lake City area from 1800-2000 UTC. Numerous thunderstorms occur over this area, two of which produce significant severe weather. The first strong storm exhibits some marginal supercell characteristics in southern Salt Lake County, where it produces 0.75-1.5” hail.

Just to the north of the intense storm in southern Salt Lake County, another cluster of cells develops on a boundary just south of the Great Salt Lake. A rotating updraft (captured on video) develops from these cells acting on the boundary, where a weak to moderate strength mesocyclone, with weak-moderate gate-gate shears, develops upward from the shear axis on the boundary, displayed well in non-operational radar data sets (TDWR). The radar depiction of rotation is hampered by the noisy velocity data around the area where the tornado develops, the long range from the radar, and the high beam height at 0.5 degrees due to the elevated radar location. A tornado develops with this storm as it moves through downtown Salt Lake City, producing primarily F1 damage with some F2 damage. One fatality and 80 injuries occurred with the tornado. The storm also produces wind gusts to 52 kts and hail to 1.5”. Numerous other storms with marginal severe hail signatures develop in the area of the Salt Lake City storm, though no severe weather is reported with the weaker storms.

A third area of convection to monitor occurs in easter Morgan County around 1921 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

A fourth area of convection to monitor occurs in easter Morgan County around 1931 UTC. Although no severe weather is reported with this storm, the radar suggests there is a threat for marginally severe hail.

Northeastern Box Elder and extreme Northwestern Cache County Multicell (1730-1945)

Time (UTC)	Description
1730 GOES-10	Isolated anvil with -38^{o}C CTT minimum.
1734 KMTX	55dBZ to 15.7kft and 50dBZ to 25 kft MSL@ 353^{o} 33 nm; Two adj cells; VIL < 30 kg/m^{2}. Weak midlevel conv N. cell.
1740 KMTX	55 dBZ to 21 kft MSL @ 357^{o} 31 nm; VIL < 30 kg/m^{2}; MEHS< 1”
1745 GOES-10	CTT min dropped to -42^{o}C.
1746 KMTX	55 dBZ to 24 kft MSL @ 357^{o} 37 nm with the northern cell.
1751 KMTX	VIL increased to 30 kg/m^{2} in northern cell.
1756 KMTX	VIL increased to 35 kg/m^{2} in middle cell; New cell dvlped in S. flank @359^{o} 31 nm; MEHS = 1” in middle cell.
1801 KMTX	VIL increased to 40 kg/m^{2} in northern end(357^{o} 40 nm). MEHS < 1”; Southern cell has 60 dBZ to 22 kft MSL (359^{o} 31 nm).
1806 KMTX	VIL down to 35 but MEHS up to 1”
1811 KMTX	OHP shows 1” at 357^{o} 37 nm; Area is on I-84.
1816 KMTX	Missing 2.4-9.9 deg slices. VIL increased to 40 kg/m^{2}
1826 KMTX	VIL remains at 40 kg/m^{2} @ 008^{o} 34 nm.
1830 GOES-10	CTT min =-47^{o}C; A well defined overshoot.
1836 KMTX	55 dBZ up to 30 kft @ 010^{o} 34 nm;
1841 KMTX	OHP shows 1.5” @ 011^{o} 36 nm;
1845 GOES-10	CTT min up to -46^{o}C; Overshoot.becomes poorly defined.
1846 KMTX	New cell forming on south flank; VIL up to 45 kg/m^{2}.
1851 KMTX	New cell becmg dominant at 011^{o} 32 nm; 55 dBZ up to 28 kft.; VIL=35 kg/m^{2}.

Time (UTC)	Description
1856 KMTX	WER on east and west flanks of new cell; OHP shows 2”.
1901 KMTX	VIL down to 30 kg/m^2;
1911 KMTX	STP up to 3”; Psbl hail contamination; 55 dBZ down to 13 kft MSL.
1915 GOES-10	No well defined CTT min; Overhead anvil around -44^{o}C.
1916 KMTX	VIL down to 25 kg/m^2; 55 dBZ only to 10 kft MSL; MEHS < 1”.
1930 GOES-10	New cell in N. Cache CO has CTT min = -48^{o}C; No well defined min for cells in far NE Box Elder CO.
1931 KMTX	VIL up to 30 kg/m^2 @ 49^o 31 nm; Cell has elevated core and is east of previous core in NW Cache CO. Western cell VIL still 25.
1935 KMTX	Eastern cell 55 dBZ up to 20 kft.
1945 KMTX	OHP decreasing in NE BoxElder CO @014^o 37 nm. STP steady at 3”, likely with minor overestimation.
1945 GOES-10	CTT min with N. Cache CO. storm = -48^{o}C; No other CTT min nearby.

Considerations:

- By 1746 UTC, does the trainee understand the reason behind the low reflectivities in the lowest slice? The trainee should recognize that beam blockage is the cause.
- Does the trainee anticipate how the beam blockage may affect the VIL and hail algorithm results? The VIL may be decreased by 10-20%, however, the hail algorithm results should not be affected because the blocked beam is below the freezing level.
- Does the trainee note the heights of the 0 and -20^{o}C levels and check to see if they are representative of the afternoon conditions? They should be representative for the morning but with the cold pool moving overhead, the heights might be overestimated.
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA algorithm, or does the trainee come up with their own estimate?
- Does the trainee use either the 4-panel or all-tilts loop to watch the height of the intense core? At 1836 UTC, the 55dBZ core extends to 31 kft MSL.

- Does the trainee notice the recurring backbuilding and echo training over the same area by around 1850 UTC?
- Does the trainee utilize the 1 hour and storm total precipitation maps and notice the 1.5-2”/hour rates as estimated by radar?
- Does the trainee use the hi-res topo map to determine if the heavy rainfall is over steep terrain?
- Does the trainee use radar-estimated rainfall in warning products? If so, are the amounts used verbatim, or are the amount modified based on the data analysis?

The Southern Salt Lake County Storm (1730-1945 UTC)

Time (UTC)	Description
1730 GOES-10	South end of -30^{o}C tops.
1734 KMTX	Two elevated 40dBZ cores @ 156^{o} 55 nm. VIL < 20 kg/m^{2}.
1745 GOES-10	Southern end of north-south oval of anvil top. Min CTT= -38^{o}C.
1751 KMTX	Cores consolidated. Ref gradient and small WER at @ 168^{o} 53 nm; 50 dBZ to 22 kft MSL;
1756 KMTX	VIL increased to 25 kg/m^{2}; Cell becomg kidney-shaped; Weak cyc circulation V_r=10kts 22kft MSL.@ 169^{o} 55 nm.
1801 KMTX	Cyc circulation weakened; 55 dBZ to 26.5 kft MSL; Small WER; VIL increased to 30 kg/m^{2}.
1806 KMTX	WER increased in width but 55 dBZ fell to 21 kft MSL;
1812 KMTX	Increased convergence at 0.5^{o} slice just west of notch;
1816 KMTX	missing 2.4-9.9 deg slice. VCP switch to 11. Conv rotation increased to V_r=15 kt in lowest two slices @162^{o} 52 nm.
1821 KMTX	55 dBZ up to 31 kft MSL; WER almost a BWER @160° 51nm on the 2.4°°slice. VIL=35 kg/m^{2};
1826 KMTX	Weak (V_r=20kt) meso lowest 3 slices. 1.5^{o} slice showed the most symmetry; VIL=40 kg/m^{2}; MEHS to 1.5”
1830 GOES-10	CTT min with overshoot = -47^{o}C; Surrounding anvil around -42^{o}C.
1831 KMTX	Meso weakened, no significant circulation. Strong WER continues @158^{o} 51 nm.

Time (UTC)	Description
1836 KMTX	Lost lowlevel inflow notch in reflectivity; Convergent signature in lowest slice. Weak rotation further aloft (V_r=10kt).
1815 LSR SLC	LSR #1; 1.5” hail in Herriman, Salt Lake CO. Note: the 1800-1815 UTC report was put here because the storm did not reach Harriman until 1815 UTC.
1841 KMTX	55 dBZ still up to 30 kft MSL; OHP shows 1.5” @ 160^o 49 nm.
1845 GOES-10	CTT min up to 46^{o}C; Still a well defined overshoot.
1846 KMTX	MEHS down to 1”; New cores forming upstream.
1851 KMTX	55 dBZ down to 20 kft MSL; MEHS < 1”; VIL down to 35 kg/m^2;
1901 KMTX	55 dBZ surged up to 30 kft MSL @ 150^o 49 nm;
1911 KMTX	55 dBZ down to 20 kft MSL;
1830-1840 LSR SLC	LSR #2; 3/4” hail in Sandy City, Salt Lake CO. Note: the time does not match the radar data.
1915 GOES-10	CTT min = -46^{o}C. Overshooting top well defined.
1916 KMTX	55 dBZ down to 11 kft MSL; VIL down to 25 kg/m^2; MEHS < 1”. STP shows 2”, likely some hail contamination. OHP~1.5-2”.
1926 KMTX	35 kt DV@ 144^o 52 nm - 1.5^o slice; No time or height continuity. Although there is a small elevated core.
1930 GOES-10	CTT min = -45^{o}C; overshoot is ill-defined.
1945 KMTX	STP at 2” with some overestimation.

Considerations:

- Does the trainee notice the onset of a WER and a sharp reflectivity gradient curved in a concave manner on the storm’s southern flank at 1756 UTC? The reflectivities are still low but the shape of the core suggests a relatively strong updraft.
- Does the trainee notice the increased velocity convergence and circulation in the lowest few slices at 1811 UTC? The values are still weak, but they suggest a strengthening updraft.
- Does the trainee notice the onset of an elevated 55 dBZ core extending up to 26 kft MSL at 1801 UTC?

- Does the trainee analyze the hail size potential of this storm and then compare it to the MEHS in the HDA?
- Does the trainee notice that this storm is accompanied by new upstream cell initiation and cell training is occurring over the area west of Sandy and I-25?
- Does the trainee notice the hourly rainfall amounts in excess of 2 inches west of Sandy and I-25?
- Does the trainee factor in hail contamination, possibility of surface drainage, and terrain if a flash flood warning is considered?

Toole-Davis County Storm (1816-1846 UTC)

Time (UTC)	Description
1816 KMTX	VIL 35 kg/m^2, MEHS 0.75”
1821 KMTX	55 dBZ to 25 Kft AGL, areal increase in 35 kg/m2 VIL, MEHS 1”, POSH and POH 100%, 1.5-2” OHP
1826 KMTX	55 dBZ to 24 Kft AGL, VIL increase to 40kg/m^2; MEHS=1.25”, 60 dBZ first appears at 4 Kft AGL
1830	IR cloud top temperature min -44^{o}C (warmer than storms to the south)
1831 KMTX	55 dBZ to 23 Kft and 40 dbz to 30 Kft
1846 KMTX	reflectivity weakens aloft as storm enters its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over the Great Salt Lake, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Salt Lake-Morgan County Storm (1830-1916)

Time (UTC)	Description
1830	IR cloud top temperature min -47^{o}C
1831 KMTX	50 dBZ to 24 Kft and 45 dBZ to 30 Kft, 60 kt gate-to-gate delta V only at lowest tilt (5 Kft AGL) and in an area of noisy velocity data, well defined divergence aloft (85 kt delta V)
1836 KMTX	50 dBZ to 29 Kft and 45 kBZ to 33 Kft, VIL 30 kg/m^2, MEHS 0.75”, weak mesocyclone-scale rotation (20-25 kts at 36 nmi) forming through a deep layer, weak TDA detection with a 56 knot LLDV
1841 KMTX	50 dBZ to 28 Kft and 45 dBZ to 34 Kft, MEHS 1”, POSH and POH 100%, weak TDA detection (50 kt LLDV) continues, velocity data less noisy, rotation increases to moderate strength (30 kt V_r at 38 nmi)
1841-1855 SLC	LSR#3: F2 tornado in Salt Lake City
1845	IR cloud top temperature min -47^{o}C expands
1846 KMTX	55 dBZ to 25 Kft, mesocyclone rotation strengthens to 35 kt V_r, weak TDA detection (58 kt LLDV) continues, VIL increase to 45 kg/m^2; MEHS=1.25”, POSH and POH 100%, large area of 55 dBZ at 5 Kft
1851 KMTX	weak 40 kt gate-to-gate low-level delta-V, rotation weakened through a deep layer
1856 KMTX	1.5-2” OHP
1900 SLC	LSR#4: G52 kts in North Salt Lake
1901 KMTX	VIL increase to 30 kg/m^2 again
1915-1920 SLC	LSR#5: 1.5” hail in Bountiful
1916 KMTX	reflectivity weakens aloft as storm moves over 8 Kft MSL mountains where it begins its demise

Considerations

- Does the trainee recognize the severe hail/wind potential with the high reflectivity cores aloft early in the storm’s lifetime?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?

- Does the trainee recognize the noisy velocity data over downtown Salt Lake City at the lowest elevation angle, and therefore put less faith in the velocity data prior to 1841?
- Does the trainee recognize the development of organized weak rotation at 1836 UTC?
- Does the trainee utilize the TDA in their analysis? If not, does the trainee recognize the weak-moderate TVS signatures in the base data?
- Does the trainee recognize the increased rotation during the 1841 and 1846 volume scans gives more credence to the tornado threat?
- Does the trainee cancel the warning prematurely when the radar signature weakens?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee anticipate the threat to diminish when the storm moves east of Salt Lake City into the mountains?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Western Toole County Storm (1921-1950 UTC)

Time (UTC)	Description
1921 KMTX	55 dBZ to 26 Kft, VIL 35 kg/m^2, MEHS 1”
1926 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft AGL, VIL 40 kg/m2, MEHS 1”, POSH and POH 100%
1930	IR cloud top temperature min -43^{o}C
1931 KMTX	55 dBZ to 26 Kft AGL and 40 dBZ to 34 Kft, VIL increase to 45 kg/m^2; MEHS=1.25”, 60 dBZ first appears at 18 Kft AGL
1935 KMTX	60 dBZ to 25 Kft AGL, 45 dBZ to 35 Kft AGL, deep 60 dBZ core, area increase in 45 kg/m^2 VIL; MEHS=1.75”,
1940 KMTX	55 dBZ to 25 Kft AGL, 45 kg/m^2 VIL; MEHS=1.25”
1945 KMTX	50 dBZ to 25 Kft AGL, 40 kg/m^2 VIL; MEHS=1.5”
1945	IR cloud top temperature min -43^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Davis County Storm (1921-2000 UTC)

Time (UTC)	Description
1916 KMTX	1.5” OHP estimate
1921 KMTX	50 dBZ to 25 Kft, VIL 30 kg/m^2, MEHS 0.75”
1926 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m2, MEHS 0.75”
1930	IR cloud top temperature min -47^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL increase to 35 kg/m^2; MEHS=1”
1935 KMTX	35 kg/m^2 VIL;
1940 KMTX	35 kg/m^2 VIL; MEHS=1”
1945 KMTX	40 kg/m^2 VIL; MEHS=1”
1945	larger area of -47^{o}C IR cloud top temperature min
1955 KMTX	30 kg/m^2 VIL; MEHS=0.75”
2000 KMTX	55 dBZ to 27 Kft, 30 kg/m^2 VIL; MEHS=0.75”

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?

- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Eastern Morgan-Rich County Storm (1931-1950 UTC)

Time (UTC)	Description
1930	IR cloud top temperature min -46^{o}C
1931 KMTX	50 dBZ to 25 Kft AGL, VIL 30 kg/m^2; MEHS=1”, POSH and POH 100%
1935 KMTX	40 kg/m^2 VIL, MEHS 1.25”, POSH and POH 100%
1940 KMTX	60 dBZ core from 11-22 Kft, 40 kg/m^2 VIL; MEHS=1.5”,POSH and POH 100%
1945 KMTX	40 kg/m^2 VIL; MEHS=1”,POSH and POH 100%
1945	IR cloud top temperature min -45^{o}C
1950 KMTX	high reflectivities aloft weaken

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Northeastern Toole County Storm (1931-2000 UTC)

Time (UTC)	Description
1931 KMTX	50 dBZ to 26 Kft AGL, VIL 30 kg/m^2; MEHS=0.75”
1935 KMTX	35 kg/m^2 VIL, MEHS 0.75”
1940 KMTX	VIL weakens to 25 kg/m^2, MEHS 0.75
1945 KMTX	MEHS=0.75”
1950 KMTX	large area of 55-60 dBZ reflectivities at 5 Kft, 50 dBZ to 24 Kft, MEHS 0.75
1955 KMTX	50 dBZ to 25 Kft, 30 kg/m^2 VIL, MEHS 0.75”
2000 KMTX	50 dBZ to 27 Kft, 40 kg/m^2 VIL, MEHS 1”, POSH and POH 100%, 1.5” OHP estimate

Considerations

- Does the trainee recognize the severe hail/wind threat with this storm even though no severe weather was reported?
- Does the trainee recognize the storm is moving over sparsely populated areas, and that severe weather reports are less likely?
- Does the trainee utilize the radar base data in addition to the algorithm data to determine the hail threat?
- Does the trainee include hail size and wind estimates in any warnings issued? If so, does the trainee use the MEHS part of the HDA, or does the trainee come up with their own estimate?
- Does the trainee check the precipitation estimates for this storm at some time during the simulation?

Appendix A: Storm Reports

I. SLC CWA Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Salt Lake County**		
	Herriman	1800 1815	**Hail(1.50)**

1 1/2 inch hail near the town of Herriman.

Rpt #	Location	Time (UTC)	Storm Characteristic
2	**Salt Lake County**		
	Sandy City	1830 1840	**Hail(0.75)**

A severe thunderstorm dropped 3/4 inch hail along Fort Union Blvd. in Sandy.

Rpt #	Location	Time (UTC)	Storm Characteristic
3	**Salt Lake County**		
	Salt Lake City	1841 1855	**Tornado(F2)**

Around lunch time, a tornado touched down in the southwest portions of Salt Lake City. The tornado intensified to an F2 on the Fujita scale, and moved northeast through the metropolitan area of Salt Lake City. It caused widespread damage at the Delta Center, then ripped across an outdoor retailers convention tent, where the lone fatality occurred along with many injuries. After blowing out many windows in the Wyndham Hotel, the tornado continued its northeast track, knocking down scaffolding and shearing off a crane at the LDS Assembly Hall construction site. Next it skirted the Capitol Building, ripping out several large trees there and in historic Memory Grove. It then moved into the residential area known as The Avenues, damaging hundreds of trees and ripping the roofs off of several homes, before finally lifting back into the clouds. All told, there was 1 fatality, 80 injured, 300 buildings and homes sustained damage, with 34 homes deemed uninhabitable. At least 500 trees were totally destroyed, with 300 more damaged. Many vehicles were damaged or totaled as well.

Rpt #	Location	Time (UTC)	Storm Characteristic
4	**Salt Lake County**		
	Salt Lake City	1900	**Thunderstorm Wind**

Thunderstorm winds gusted to 60 mph (52 kts) in North Salt Lake.

Rpt #	Location	Time (UTC)	Storm Characteristic
5	**Davis County**		
	Bountiful	1915 1920	**Hail(1.50)**

After producing the Salt Lake tornado, that same cell dropped 1 1/2 inch hail in Bountiful.

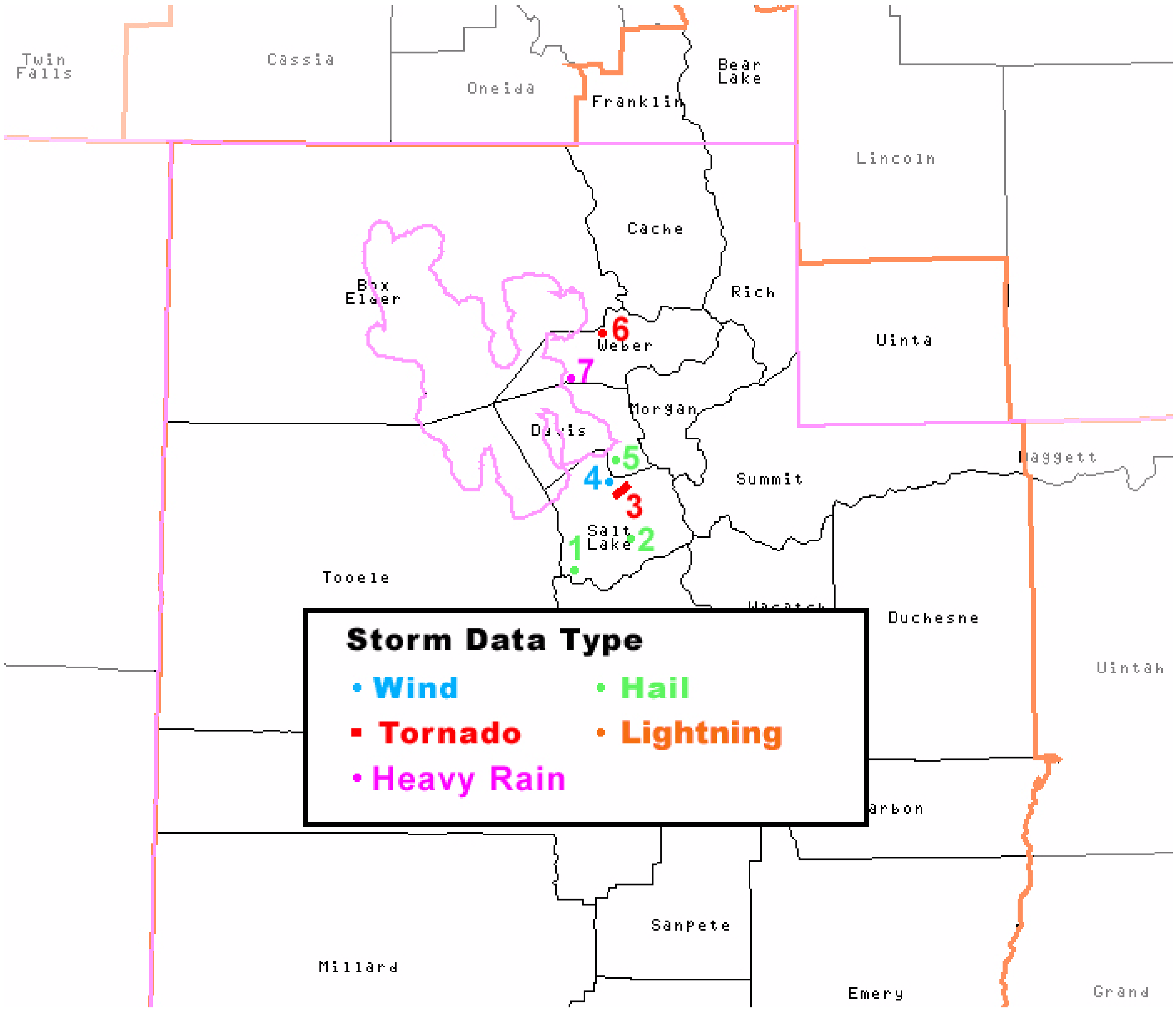
Rpt #	Location	Time (UTC)	Storm Characteristic
6	**Weber County** North Ogden	2000 2100	**Funnel Cloud**

A funnel cloud was spotted near Ben Lomond in Weber County.

Rpt #	Location	Time (UTC)	Storm Characteristic
7	**Weber County** Hooper	2000 2010	**Heavy Rain**

A downpour in Hooper, as a thunderstorm dumped .60 inches of rain in 10 minutes.

II. Storm Data for SLC CWA from 1700 UTC through 2000UTC on 8/11/99



Appendix B: SPC Products

I. Day 1 Convective Outlook

ZCZC MKCSWODY1 000
ACUS1 KMKC 111627
_MKC AC 111627

CONVECTIVE OUTLOOK...REF AFOS NMCGPH94O.

VALID 111630Z - 121200Z

THERE IS A SLGT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM
25 NNW GUP 40 NNW 4BL 25 SSE RKS RWL 40 W FCL 45 N ALS 35 ENE 4SL
40 NNE GNT 25 NNW GUP.

THERE IS A SLGT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM
40 ENE GAG 30 N LBL 25 SW LBF 60 NW MHN 40 SSW RAP 25 SW 81V
55 SE BIL 30 ENE BIL 60 NW MLS 35 NW BIS 55 E FAR 40 S DLH
30 ENE LSE 35 SE CID 15 SSE STJ 20 ESE ICT 40 ENE GAG.

THERE IS A SLGT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM
20 SSE OAJ RWI 40 WSW RIC 25 ESE DCA 15 SE NEL.

GEN TSTMS ARE FCST TO THE RIGHT OF A LINE FROM 35 WSW FHU 45 W E03
30 SSE PGA 20 NE CDC ELY 20 W U31 20 ESE MHS 25 NNE MFR 30 ESE DLS
15 WNW EPH 40 NW 63S ...CONT... 20 NE IWD MKE CGX 15 WSW BMG
40 E BWG 20 NNW TYS HSS PSK 30 NW AOO 25 W ALB PSM ...CONT...
25 ESE PSX 40 W LFK 35 ESE DAL 40 N MWL 60 NNW ABI BGS 15 NNE FST
70 S MRF.

...SEVERE THUNDERSTORM FORECAST DISCUSSION...

...CENTRAL/NRN PLAINS...
VERY COMPLEX PATTERN STILL EVOLVING THIS MORNING. PRIMARY SURFACE
LOW WAS CENTERED NEAR ERN MT/WY BORDER AT 14Z WITH ALMOST
STATIONARY FRONT EXTENDING THROUGH SRN MN AND ALONG SD/ND BORDER.
LEE TROUGH EXTENDED SWD THROUGH WRN PORTIONS OF SD/NEB/KS WITH
OUTFLOW BOUNDARY FROM W CENTRAL MO TO W CENTRAL KS FROM OVERNIGHT

CONVECTION.

UPPER WAVE FORECASTED TO MOVE ACROSS CENTRAL ROCKIES THIS AFTERNOON WITH ASSOCIATED MID LEVEL COLD ADVECTION/DYNAMIC LIFT SPREADING INTO THE PLAINS LATE THIS AFTERNOON/EARLY THIS EVENING. LOW LEVEL SLY FLOW WILL MEANWHILE PERSIST E OF THE LEE TROUGH AXIS THROUGH THE AFTERNOON WITH ASSOCIATED LOW LEVEL THETAE ADVECTION FROM KS TO SD. VISIBLE SATELLITE IMAGES ALSO SHOWING CLEARING SKIES OVER MUCH OF KS/NEB WHICH WILL ALLOW MUCH OF RAIN COOLED AIR MASS TO RECOVER. ETA FORECASTED SURFACE DEWPOINTS LOOK TOO HIGH OVER KS/NEB/SD BUT STILL EXPECT AFTERNOON DEWPOINTS MID 60S TO LOWER 70S. THIS FACTOR PLUS WARM ADVECTION/SOLAR HEATING WILL PUSH MUCAPES AOA 3000 J/KG BY LATE AFTERNOON.

TIMING OF CONVECTION IN WARM SECTOR A MAIN UNCERTAINTY DUE TO SOME INITIAL CONVECTIVE INHIBITION. AT THIS TIME BELIEVE STRONGEST ACTIVITY WILL INITIATE LATE THIS AFTERNOON/EARLY TONIGHT AS SHALLOW FORCING ALONG LEE TROUGH IS SUPPLEMENTED BY UPPER FORCING IN ADVANCE OF UPPER WAVE. MID LEVEL FLOW WILL INCREASE TO NEAR 40 KT OVER 30 KT LOW LEVEL JET WHICH...GIVEN THE HIGH CAPE VALUES...WILL SUPPORT ISOLATED TORNADOES. OTHERWISE EXPECT SCATTERED LARGE HAIL AND DAMAGING DOWNBURSTS.

FURTHER N...EXPECT MAINLY ELEVATED SEVERE THUNDERSTORMS WITH LARGE HAIL N OF FRONT ACROSS MN/ND.

...MID ATLANTIC STATES...
VERY WARM HUMID AIR MASS EXTENDS ACROSS DE AND ERN PORTIONS OF VA/NC WITH AFTERNOON TEMPS AROUND 90 AND DEWPOINTS IN 70S RESULTING IN HIGHLY UNSTABLE AIR MASS AND MUCAPES ABOVE 4000 J/KG. LATEST SATELLITE DATA ALSO INDICATES DRIER AIR MOVING INTO REGION AT MID LEVELS. LEE TROUGH AT SURFACE AND WEAK UPPER WAVE APPROACHING FROM THE W SHOULD SUPPORT SCATTERED CONVECTION WITH 30 KT MID LEVEL FLOW PROVIDING ENOUGH SHEAR FOR SOME UPDRAFT ENHANCEMENT. COMBINATION OF HIGH INSTABILITY...ABUNDANT LOW LEVEL MOISTURE AND DRY AIR ALOFT WILL SUPPORT BOTH DAMAGING WET DOWNBURSTS AND LARGE HAIL.

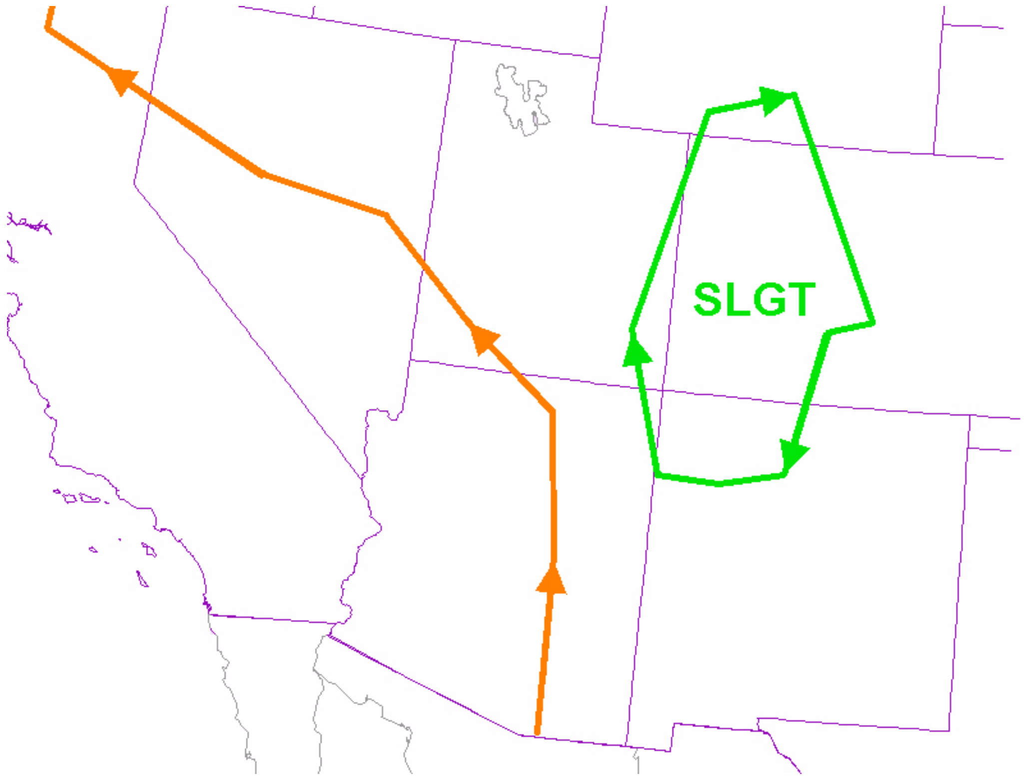
...WRN CO VICINITY...
AIR MASS WILL DESTABILIZE THIS AFTERNOON AS CLEARING SKIES/HEATING AND MODERATE LOW LEVEL MOISTURE WILL RESULT IN MUCAPES INCREASING TO 1000 TO 2000 J/KG THIS AFTERNOON. HIGH TERRAIN AND APPROACHING UPPER WAVE WILL THEREFORE SUPPORT AT LEAST SCATTERED CONVECTION THIS AFTERNOON/EVENING. MID LEVEL DRY AIR ADVECTION VERY EVIDENT ON

LATEST WATER VAPOR IMAGES AND UPPER AIR ANALYSES INDICATING POTENTIAL FOR A FEW DAMAGING DOWNBURSTS. IN ADDITION...MID LEVEL COLD ADVECTION WILL SUPPORT MARGINALLY SEVERE HAIL.

..ROGASH.. 08/11/99

NNNN

1627 UTC Convective Outlook on 08/11/99



II. Severe Thunderstorm Watches

ZCZC MKCSEL9 ALL 120100;385,1125 425,1104 425,1071 385,1093;
WWUS9 KMKC 111952
_MKC WW 111952
UTZ000-WYZ000-120100-

URGENT - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WATCH NUMBER 629
STORM PREDICTION CENTER NORMAN OK
152 PM MDT WED AUG 11 1999

THE STORM PREDICTION CENTER HAS ISSUED A
SEVERE THUNDERSTORM WATCH FOR PORTIONS OF

CENTRAL AND NORTHEASTERN UTAH
SOUTHWESTERN WYOMING

EFFECTIVE THIS WEDNESDAY AFTERNOON AND EVENING FROM 215 PM UNTIL
700 PM MDT.

HAIL TO 1 INCHES IN DIAMETER...THUNDERSTORM WIND GUSTS TO 70
MPH...AND DANGEROUS LIGHTNING ARE POSSIBLE IN THESE AREAS.

THE SEVERE THUNDERSTORM WATCH AREA IS ALONG AND 90 STATUTE MILES
EAST AND WEST OF A LINE FROM 70 MILES EAST SOUTHEAST OF DELTA UTAH
TO 15 MILES WEST NORTHWEST OF LANDER WYOMING.

REMEMBER...A SEVERE THUNDERSTORM WATCH MEANS CONDITIONS ARE
FAVORABLE FOR SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA.
PERSONS IN THESE AREAS SHOULD BE ON THE LOOKOUT FOR THREATENING
WEATHER CONDITIONS AND LISTEN FOR LATER STATEMENTS AND POSSIBLE
WARNINGS.

DISCUSSION...THUNDERSTORMS INCREASING AHEAD OF UPPER LEVEL TROUGH
AS IT APPROACHES REGION. COOLING ALOFT HAS RESULTED IN MODERATE
INSTABILITY WITH CAPES FROM 1000 TO 2000 J/KG. MARGINAL WIND SHEAR
INDICATES PRIMARY THREAT OF LARGE HAIL AND WIND DAMAGE.

AVIATION...A FEW SEVERE THUNDERSTORMS WITH HAIL SURFACE AND ALOFT
TO 1 INCHES. EXTREME TURBULENCE AND SURFACE WIND GUSTS TO 60
KNOTS. A FEW CUMULONIMBI WITH MAXIMUM TOPS TO 500. MEAN STORM
MOTION VECTOR 22030.

...ROGASH

;385,1125 425,1104 425,1071 385,1093;

NNNN

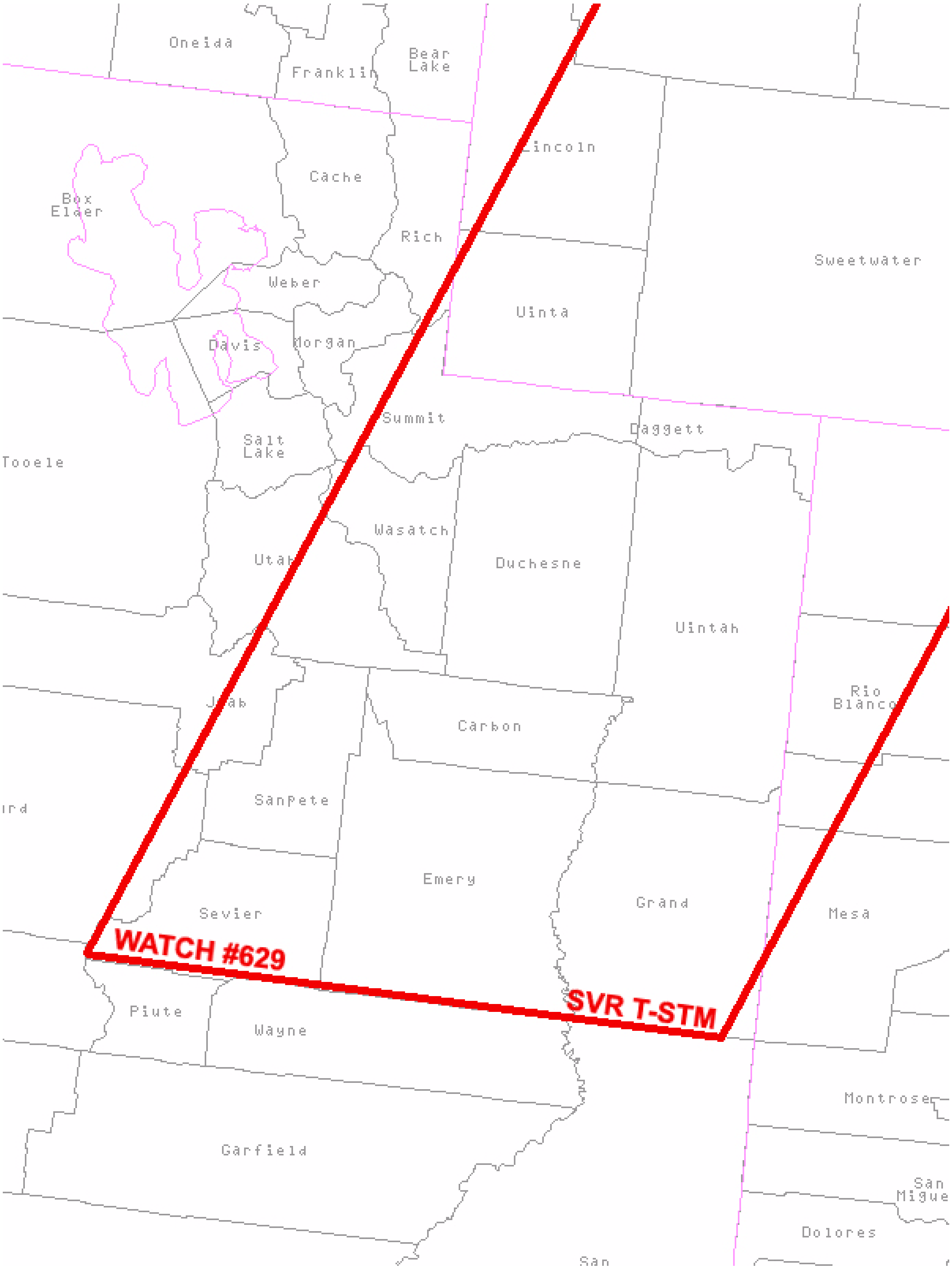


Figure B-1. Severe Thunderstorm Watch #629.

Appendix C: Support Materials

This Appendix includes:

A sample warning log provided for use in the simulations (see page C-2).

A map of the Salt Lake City CWA (see Figure C-2 on page C-3).

Mesonet Plot of surface temperatures, winds and gusts (see Figure C-3 on page C-4).

Team Members: **Warning Log** **Today's Date**

___________/___________ Simulation Location/Date ________________ Page #_____________

Warning Type
Tornado - T
Svr Tstm - S
Flash Flood - F
Svr Wx Statement - SVS
Nowcast - NOW

List Basis for Warnings (In order of importance):
1 - Reflectivity; 2 - SRM; 3- Base Velocity;
4 - MESO; 5- TVS; 6 - VIL; 7- Precip; 8 - Other Alg
9 - Loop; 10 - Report; 11 - Other (explain)

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

Figure C-1. Warning Log Form.

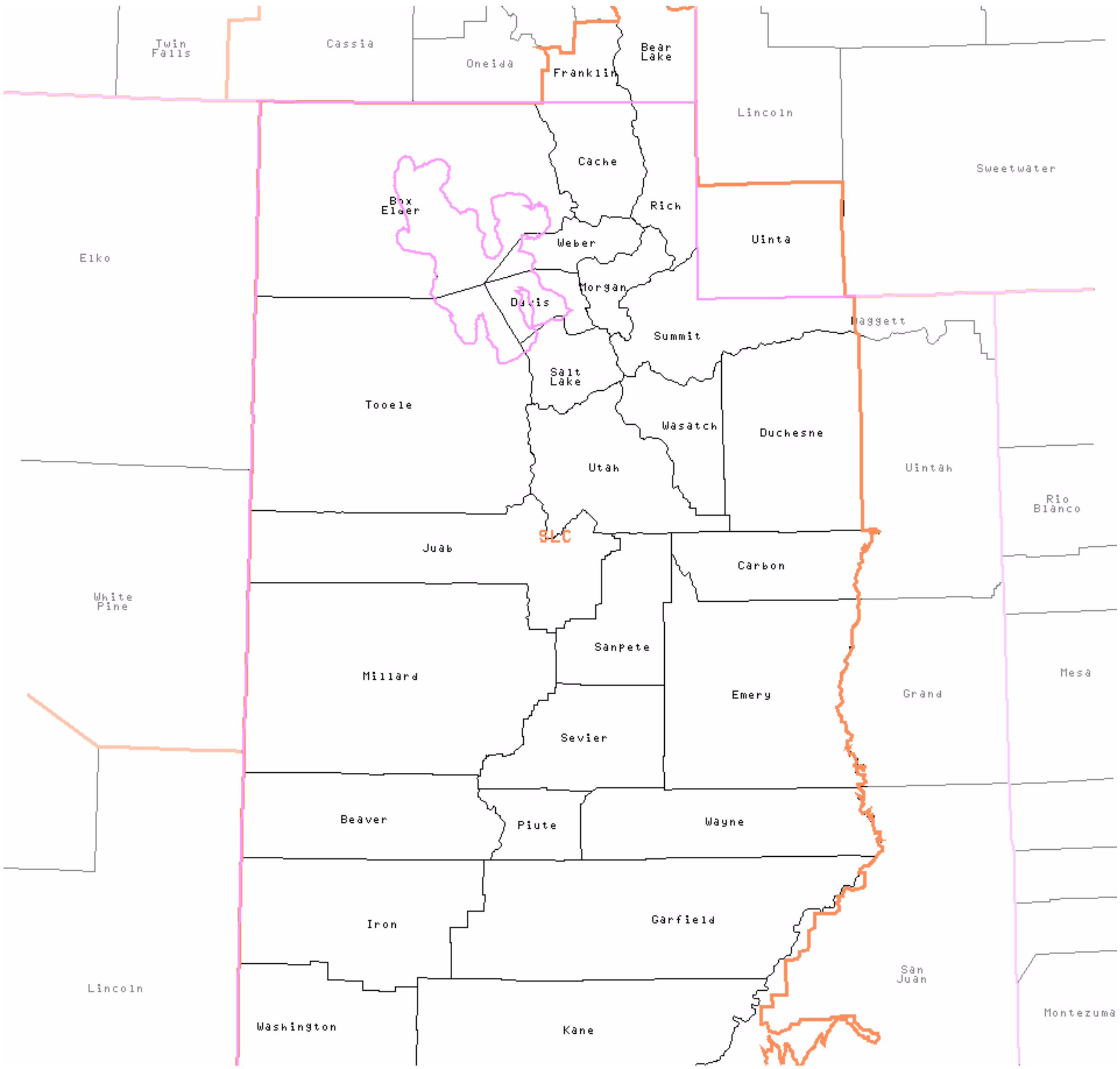


Figure C-2. A map of the Salt Lake City CWA.

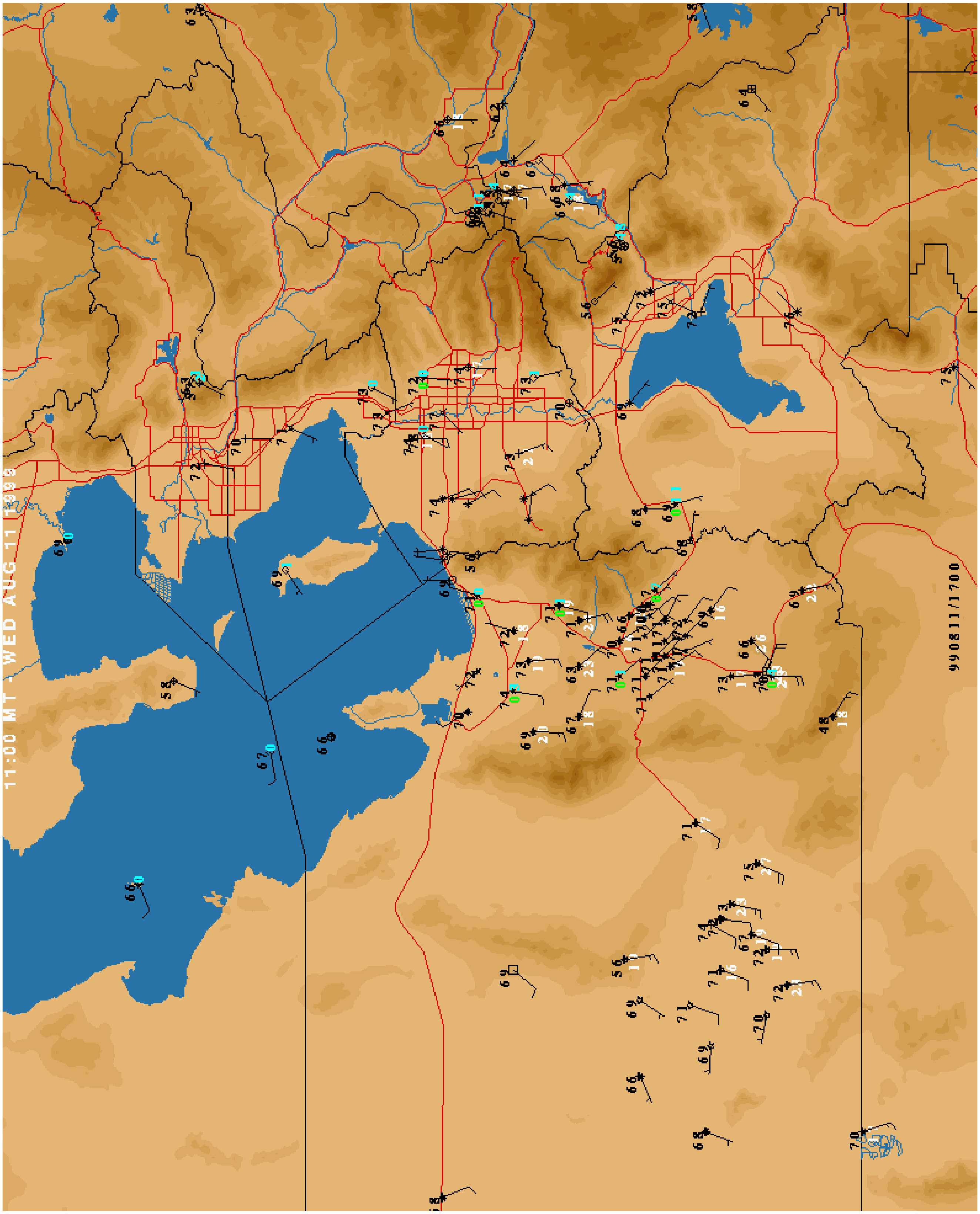


Figure C-3. Mesonet Plot of surface temperatures (F), winds (kts) and gusts (kts, white number).